

SECTION 10.0 FEATURE FORMATION: BASINS

INTRODUCTION

One of the most ubiquitous feature types at Hickory Bluff were basin features of varying sizes and shapes. While culturally constructed basin features may sometimes be differentiated from natural features based on their observed morphology and content, postdepositional processes operate to modify and mimic cultural features, causing problems in determining specific formation of the entity. Moreover, since cultural and natural agents often overlap and interact in the context of basin formation and use, it is worthwhile to consider these archaeological manifestations as the result of complex processes.

The formation of basin features is of particular relevance to archaeological investigations in Delaware. Extensive archaeological work in the state has resulted in the identification of thousands of basin features, the exact nature of which remain undetermined. During the past decade, there has been an on-going debate among archaeologists working in the state concerning the interpretation of these subsurface soil anomalies. Many hundreds of these anomalies have been excavated on sites in Delaware; over two hundred large pits were reported from the Leipsic site (Custer et al. 1994), with hundreds more reported from both Carey Farm and Island Farm (Custer et al. 1995b). These anomalies have been identified as the signature remains of semi-subterranean dwellings, or “pit houses” (Custer et al. 1994:36-38; Custer and Silber 1995; Custer et al. 1995b). Others have suggested that they are the remnants of naturally occurring tree throws (e.g., Mueller and Cavallo 1995).

The formation of basin features was examined using a variety of research avenues. Ethnohistorical and experimental sources were reviewed and three-dimensional computer maps of basins and tree anomalies were created to examine the range of variation found within feature types. The information gathered from these sources was synthesized and used to model the various processes that may have operated to form basin features.

Prior to addressing possible basin formation, a brief review of the archaeological evidence for semi-subterranean dwellings, or pit houses in Delaware is reviewed. This is followed by a synopsis of the tree throw alternative for the formation of large basin features. In that context, existing scientific documentation of tree throw morphology is presented in detail. Archaeological documentation of extant tree disturbances on Hickory Bluff is then presented. The purpose of this study was to assess the actual below ground configurations of local tree species in order to gain insights into the precise nature of their archaeological traces. The morphology of modern tree throws on Hickory Bluff and other nearby sites is also documented. The next component in the investigation of potential basin formation details the results of the experimental undertakings. This study provides insights in to the progressive morphological changes that occur to, and within, replicated basin feature excavations over time. Information provided by this study proved valuable in assessing what changes occur to excavations and how a known basin morphology may differ from its original form when encountered in archaeological contexts. The range of morphology and variation within both basin features and the documented tree disturbances are presented and illustrated with the aid of computer generated three-dimensional contour maps. These maps helped to visualize the differences within and between feature types and more accurately depict the encountered archaeological residues.

SEMI-SUBTERRANEAN STRUCTURES IN DELAWARE

Archaeological remains of semi-subterranean shelters were first reported at the Poplar Thicket (7S-G-22) and Island Field (7K-F-17) sites (Griffith and Artusy 1975). At Poplar Thicket, a large, shallow rectilinear pit feature was excavated. This pit, which measured 3.0 by 3.8 Meters (m), showed very regular, steeply sloping sides and a flat bottom. Internal features, including a central hearth and numerous post molds, were also recorded (Griffith and Artusy 1975:5). The Island Field example was similar in dimension, though it was oval in plan. An internal hearth and post molds were present (Griffith and Artusy 1975:6). Both these features contained Townsend series ceramics, dating them to the Late Woodland period.

Very large ovoid to rectangular flat-bottom pits were also reported from the Mispillion site (7S-A-1) and the Warrinton site (7S-G-14) (Griffith and Artusy 1975). Illustrated examples from the respective sites had maximum lengths of 3.6 m and 3.2 m (Griffith and Artusy 1975:2-3). Though lacking obvious internal features, these large pits were also interpreted as the remains of semi-subterranean shelters. At least one example from each site contained Townsend Series ceramics and triangular projectile points (Griffith and Artusy 1975:1-2).

Investigations at the Delaware Park site in New Castle County identified nearly 200 subsurface pit features of various sizes (Thomas 1981). Four of these features were interpreted as possibly representing “domiciles” or “shelters for some other human activity” (Thomas 1981:V-17). These features, categorized as Type B, were very large shallow basins with both sloping and flat bottoms. Feature 94, illustrated and described in detail in the report, contained a small pit interpreted as an internal hearth. Also noted during excavation were possible interior and exterior post molds and a degree of compaction of the pit floor (Thomas 1981:V-17). A radiocarbon date of 1850 B.C. was obtained from Feature 94, while a second Type B feature yielded a date of 790 B.C. (Thomas 1981:IV-44).

A possible pithouse finding was also documented at the Clyde Farm Site (7NC-E-6A) (Custer 1989). On Clyde Farm “in an area of approximately thirty-five square meters, a number of features were discovered including a platform hearth, possible storage pits, and a pit house” (Custer 1989:197). A single radiocarbon date of 1005 B.C. was obtained from the platform hearth. Based on their horizontal spatial association, these features were collectively interpreted as a household cluster (Custer 1989:198). In that regard, the large pit (house) feature, the platform hearth and a storage pit, together with a conjectural area of tool production, were illustrated as an idealized “Feature Plot” (Custer 1989:187). The concept of household clusters was used to interpret the numerous subsurface anomalies found on Snapp, Carey Farm, Leipsic and other site locations where anomalies were seen as the signature remains of plow truncated semi-subterranean dwellings (Custer 1994:50-66).

The conceptual template for large basins representing pit houses was based on a single finding made on the Snapp site (7NC-G-101) where a complex of features was encountered at the foot of a minor slope. The addition of colluvial soil had protected this area from the extensive plow truncation evident across the rest of the site. Designated Feature 153, the complex consisted of a large D-shaped basin set in one end of a much larger, shallow feature. A third pit was defined in the approximate center of the larger feature. The cluster of pits was roughly enclosed by a pattern of nine, irregularly spaced post molds. The Feature 153 complex was interpreted as a dwelling composed of a shallow “basement”, or living area, with a “sub-basement” storage

facility located at one end. The central pit was interpreted as a hearth, with the post mold pattern representing a superstructure constructed over the below-grade house floor (Custer and Silber 1995:43-52).

The interpretation of a remnant “sub-basement” within a semi-subterranean structure was applied to a large number of the Snapp anomalies (Custer and Silber 1995) and extended to other sites on which similar anomalies were present (Figure 10.1). According to this model, virtually all of the hundreds of large anomalies identified on these sites represent house locations (Custer et al. 1994; Custer and Silber 1995; Custer et al. 1995b). On the Leipsic site alone, a total of 197 individual anomalies were interpreted as sub-basement storage facilities located within dwellings, all other traces of which have been lost to extensive plowing and soil deflation (Custer et al. 1994:36-38). Further, the “household cluster” definition is applied to many of the anomaly locations. The incidence and frequency of these “household clusters” was then used to make broad inferences on site function, occupation seasonality and regional settlement patterns (Custer et al. 1994; Custer and Silber 1995; Custer et al. 1995b).

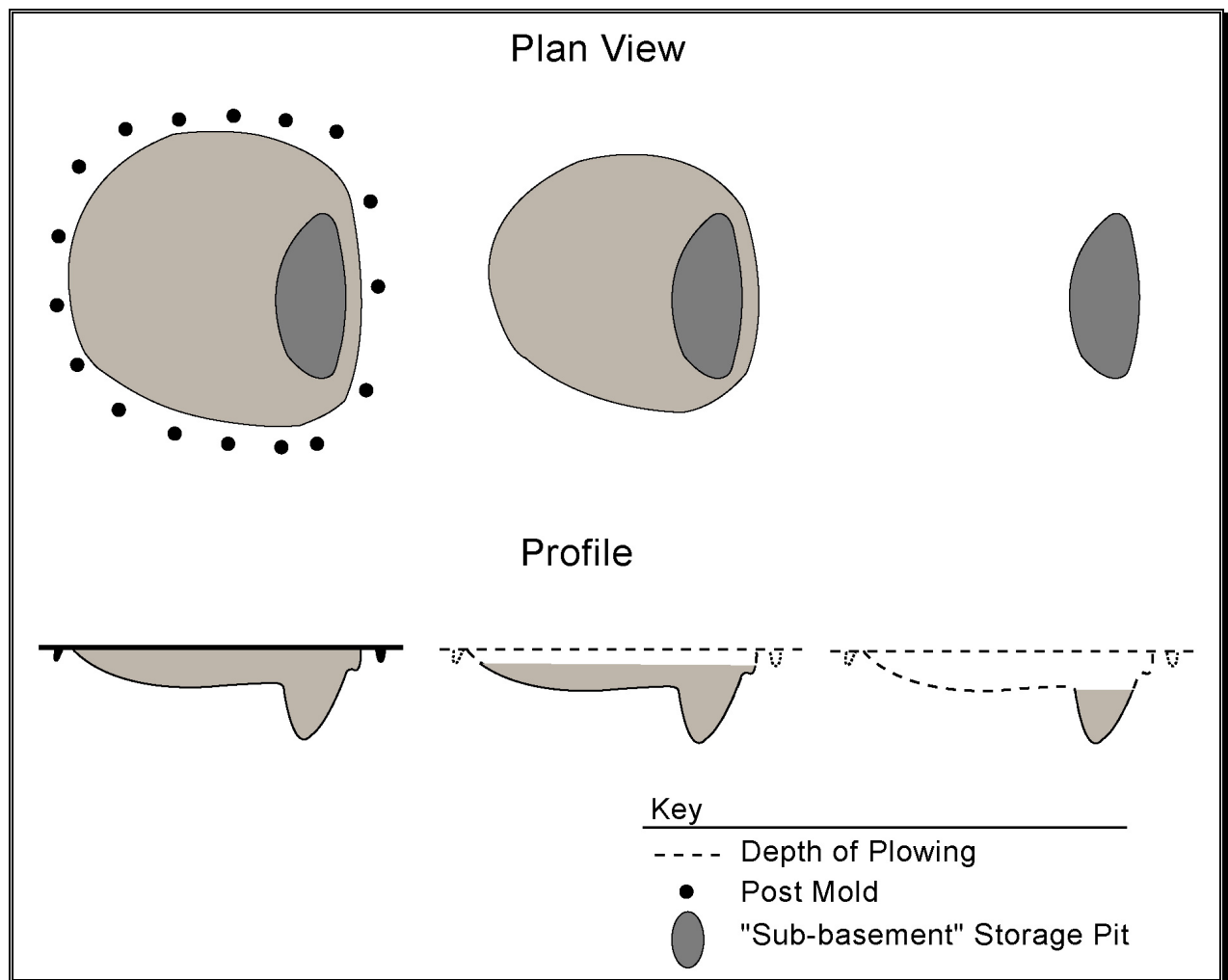


Figure 10.1 Proposed Taphonomy of Delmarva Pithouse Features (Custer 1994: Figure 30)

THE ROLE OF TREES

The Tree Throw Alternative

The tree throw hypothesis for similar archaeological feature phenomena was indicated at the Hollingsworth Farm site along Elk Creek in Elkton, Maryland (Thomas and Payne 1981). Thirty-seven of the large features investigated during excavations were interpreted as tree throws. These pit features were typically circular to ovoid in shape with rounded or irregularly shaped bottoms and were characterized by inclusion of dark, organic-laden soils and concentrations of Native American artifacts mixed with occasional historical artifacts (Thomas and Payne 1981). During subsequent excavations conducted at the Charles Robinson Plantation in New Castle County (Thomas 1982), thirty D- or kidney-shaped subsurface anomalies were identified, all of which had been truncated by plowing. Thomas suggested that tree throws might be the causal factor in the creation of these and other similar features commonly encountered elsewhere within the state of Delaware.

More recently, Mueller and Cavallo have explored the alternative tree throw hypothesis as a result of excavations conducted by Rutgers University at the Gabor site in northern Delaware (Cavallo n.d.). Several D-shaped proposed “pit house” features were interpreted as naturally occurring tree throws due to lack of organic staining, internal stratigraphy, associated post molds, and paucity of artifacts (Mueller and Cavallo 1995). A review of publications, related to natural tree throws and archaeological investigations of unequivocal semi-subterranean pit houses and other D-shaped features, was conducted. These investigators concluded that, based on all available evidence, the most reasonable interpretation of the D-shaped pits was that they were a result of naturally occurring tree throws and not cultural activity. These findings were presented in papers at the 1995 meetings of the Archaeological Society of New Jersey (Cavallo 1995) and the Eastern States Archaeological Federation (Mueller and Cavallo 1995).

Subsurface Tree Physiology and Morphology

A tree's roots comprise an elaborate and sophisticated system that performs three basic functions: to absorb moisture and soil nutrients, to transport these materials, and to provide anchorage and support. While the above ground portion of a typical mature tree is easily observed, a vast root system lies hidden below ground. For example, a single rye plant has been shown to possess 14 million individual roots collectively totaling over 375 miles in length (Farb 1961:95). By comparison, the total extent of a mature hardwood tree's root system is so vast that it would be a near impossible task to measure it. Deciduous tree species such as oaks, hickories, and walnuts have systems that could be thought of as foreshortened mirror image of the tree's crown. Roots continually branch in all directions, with each branch carrying its own growing tip (Farb 1961:95). These growing tips, which can number in the millions, essentially possess a sensory function. They act like a probing finger, actively avoiding hard objects and seeking out soft earth which they penetrate with a corkscrew motion (Farb 1961:94).

The absorption function of the root system is carried out by thousand of tiny root hairs that extend out perpendicularly from a short stretch of new root just behind the growing tip. This area just behind the growing tip is the only portion of the root that actively grows in length (Farb 1961:94). These new roots, which have a diameter of no more than a piece of string, function in an absorbing capacity for only a short time. After a few weeks, the root hairs die and the root

ceases to absorb. From then on, the root grows in diameter only and its role remains to provide transport and anchorage (Farb 1961:94). In this manner, a tree must continually branch out new small thin new roots that seek out water and essential nutrients. Over time, these new roots grow to form a vast web that essentially develops in situ.

The anchoring ability of a tree root system is particularly remarkable when one considers that a mature trunk can reach upwards of a hundred or more feet, after which it branches out into a wide crown. Not only does this represent a huge mass, but the crown acts like a sail under windy or stormy condition. Further yet, this force is applied to the base of the trunk where the ground can act as a fulcrum point. Much of the stability exhibited by large trees comes from the mature roots that radiate out in all directions just below the surface, acting as guy wires, while additional anchorage is provided by tap roots that can plumb considerable depths (Farb 1961:95). While the major root elements can extend outwards as far as the edge of the crown, and can also penetrate to considerable depths, the actual immobilizing strength of the root system comes from the vast web of tiny root that spread out from the larger, main root members. The tip areas of these smallest roots contain untold numbers of root hairs that grip the soil so tenaciously that they cannot be removed without being broken (Farb 1964:94).

The Morphology of Tree Throws

The large majority of tree throw studies have been conducted within the fields of forestry and ecology, undertaken to determine the impact of tree throws on the forest environment and subsequent pedogenic processes. A review of this literature revealed a wide variety of surface and subsurface morphologies resulting from tree throws, dependent on many climactic and pedological conditions.

Four primary factors have been identified as creating tree throws: wind, weight of ice or snow, the fall of an adjacent tree, and people (Langohr 1993). Wind-related tree throws may result in the breaking of the tree trunk or the uprooting of the entire tree (Langohr 1993). Environmental variables associated with wind-related tree throws include seasonal wind intensity, storm events (i.e., hurricanes and tornadoes), precipitation (affecting soil saturation and stability), landform, and depth to bedrock. The last two variables also contribute to the variation in tree root systems.

Typically, a tree throw forms a paired pit and mound, or cradle and knoll topography. The pit, or cradle, is formed as tree roots are ripped from the soil, carrying with them surrounding sediments that cling to the root mass. As the displaced root plate decays, soil slumps back into the pit and onto the undisturbed adjacent ground surface forming a mound, or knoll, that marks the resting place of the fallen tree (e.g., Lutz 1960; Schaetzl et al. 1990; Wood and Johnson 1978). Tree throws are commonly identified by the presence of these pit/mound pairs and are widespread throughout forested regions (Beke and McKeague 1984; Cremeans and Kalisz 1988; Stephens 1956). Eight variations of tree throws and their associated soil stratigraphies have been identified (Langohr 1993) (Figure 10.2).

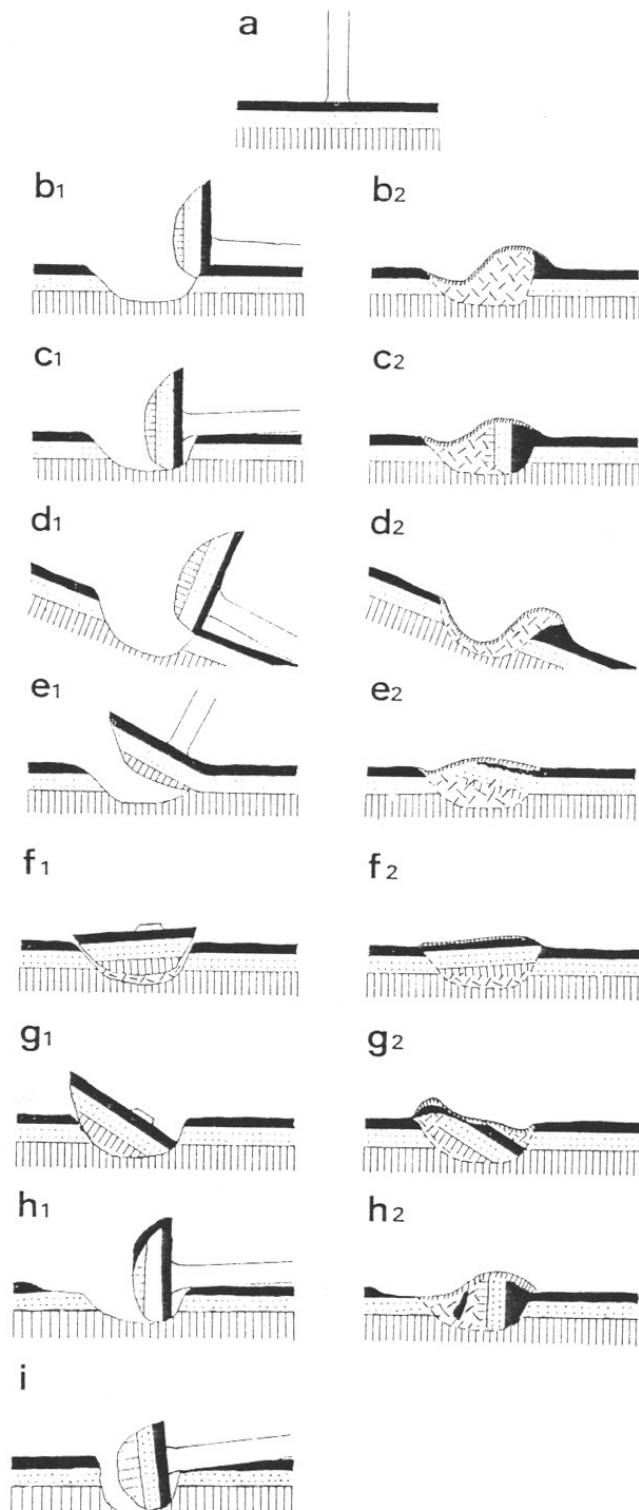


Figure 10.2 Eight Variations of Tree Throws and Associated Stratigraphies
(Langhor 1993: Figure 1)

Studies of the size and depth of tree throw pits have shown that initial dimensions depend largely upon the size of the tree and its root structure. Conversely, the quantity of sediment that returns to the pit through slump and wash processes will determine its later dimensions (Beatty and Stone 1986; Putz 1983). Many varied factors affecting the slump and wash process must be taken into account in any tree throw study. These factors include soil characteristics such as texture, structure, and gravel content; regional climate (e.g., precipitation rates and freeze-thaw activity; decay rate of the root mass); and faunalurbation both within the pit and adjacent mound (Lyford and MacLean 1966; Putz 1983). Ground slope is yet another variable that determines the rate and amount of pit infilling. On gentle slopes, pits are often partially or completely refilled by uplifted soils (Denny and Goodlett 1956; Schaetzl and Follmer 1990), whereas trees that fall on steep slopes generally fall downslope and are infilled by slopewash and gravity-transported sediments (Cremeans and Kalisz 1988).

Tree throws may also be classified according to the shape and placement of the resulting pits. Simple tree throw pits appear ovoid to D-shaped in plan-view, but are almost never circular (Langhor 1993) (Figure 10.3). Crescentic pits may be caused by slight backward displacement during treefall (Beatty and Stone 1986), though this may simply be a result of incomplete data recovery (Langhor 1993). Partial, but incomplete backward displacement of the root mass may cause the formation of two smaller pits on either side of a mound (Nielson 1963). Complete backward displacement may form a pit on the lee side of the mound, thus complicating future determination of the direction of the tree throw (Schaetzl et al. 1989). Nielson (1963) has also suggested that the latter pit-mound arrangement is caused by trees falling against other nearby trees, by trees falling upslope, or by large boulders present near the base of the tree that act as pivot points during the treefall process. Tree throw cradle profiles exhibit a characteristic morphology: one edge is steep-sided and the other is gently sloping. The steep-sided deepest portion indicates the leeside of the tree throw whereas the gentle sloping shallow side represents the windward side (Crombe' 1993).

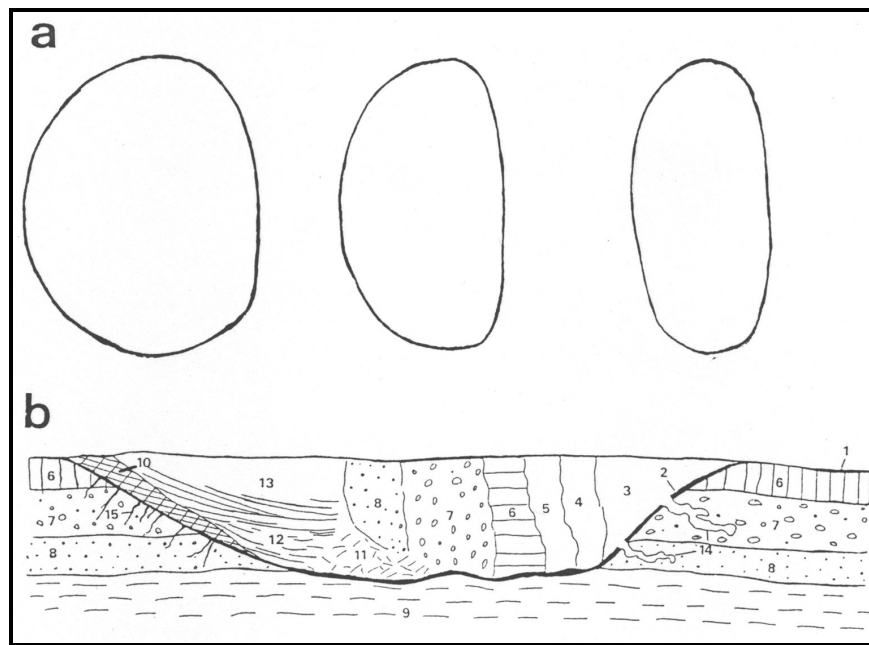


Figure 10.3 Typical Planview and Profile of Three Throws (Langhor 1993: Figure 2)

Tree throw mounds are characterized by the slope of their sides or the relief from the mound crest to the pit bottom. Due to erosion and other infilling processes, mound distinctiveness decreases significantly over time (Denny and Goodlett 1956). Sediment characteristics aid in determinations of both mound longevity and slope deterioration. In a comparative study, Nielson found that mounds formed in silty sediments had a steeper average slope (14°) than did those that occur in sandier soils (10°). Stone (1975) observed slopes of 13.30° on mounds formed in gravel-free soils that were estimated to be over 250 years old (cited in Schaetzl et al. 1990). The horizontal relationship between mound crest and pit bottom also changes over time, as sediments from the mound fall into the nearest part of the pit, progressively shifting the deepest point away from the crest of the mound (Schaetzl et al. 1990).

As previously noted, the amount of soil disturbed is largely dependent on the size of the tree uprooted and the structure of its root system. The uprooting of large trees will result in the disturbance of a greater surface area than small ones, though they will not necessarily cause disturbance of a greater depth (Hall 1988). The extent of the disturbance also depends on the health of a tree when it falls. Dead or dying trees will cause less significant disturbance than healthy trees, as root breakage during uprooting will be greater when the root system has already begun to decay (Swanson et al. 1982). Several studies have been conducted correlating trunk diameter at breast height (DBH) to area of soil disturbed by uprooting. Cremeans and Kalisz (1988) found a positive correlation between DBH and the area of disturbance, calculating separate regressions for both healthy and dead trees. Burns (1981) also examined patterns of size vs. disturbance and found that the area disturbed increases up to approximately 40 centimeters (cm) DBH, but that root systems of larger trees did not typically affect a larger subsurface area.

Primary pedoturbation results from the slump and erosion of sediments clinging to the root plate. Uplifted soil horizons may appear discontinuous and irregular within areas of redeposition (Johnson et al. 1987) (Figure 10.4), or may appear as an interfingering of disturbed soil horizons (Hall 1988; Lutz and Griswold 1939). The appearance of redeposited soils largely depends upon the rate of decay of the root plate itself. Under circumstances of prolonged decay, soil horizons become homogenous due to slowed slump and wash processes, resulting in total loss of the distinctiveness of original horizons (Schaetzl et al. 1990). In contrast, rapid decay of the root mass, as is common in hardwoods (Beatty and Stone 1986), produces a more heterogeneous pattern of redeposition. Soil falls from the root mass in clumps too quickly for surface pedoturbation processes to cause significant mixing of disturbed horizons (Hall 1988; Troedsson and Lyford 1973). Soil horizons may appear folded over one another (Beatty and Stone 1986; Lutz and Griswold 1939; Veneman et al. 1984). Complete inversion of original soil profiles may occur on steep slopes where uprooted trees fall downhill (Figure 10.2), particularly in cases where fires subsequently occur (Figure 10.5). As the trunk decays or is burned, the root plate falls upside-down, resulting in inverted stratigraphy (Schaetzl 1986).

Gravels, rocks, and large soil clasts, where present, are also brought to the surface along with uprooted sediments (Lutz 1960). These inclusions are subsequently reburied within redeposited soils by slope and wash processes. Archaeological artifacts found within disturbed horizons are also mixed and reburied by the same processes of pedoturbation (Wood and Johnson 1978). Frequently, patterns of redeposition of soil inclusions can indicate the presence of tree throws long after all resulting surface topography has been obliterated (Beatty and Stone 1986). As sediments wash from the root plate, gravels and other inclusions may be concentrated

as an armor or lag (Denny and Goodlett 1956; Johnson 1990) (Figure 10.6). Uprooting may also form mounds of surface stone pavements surrounded by fine sediments and vice versa (Denny and Goodlett 1956).

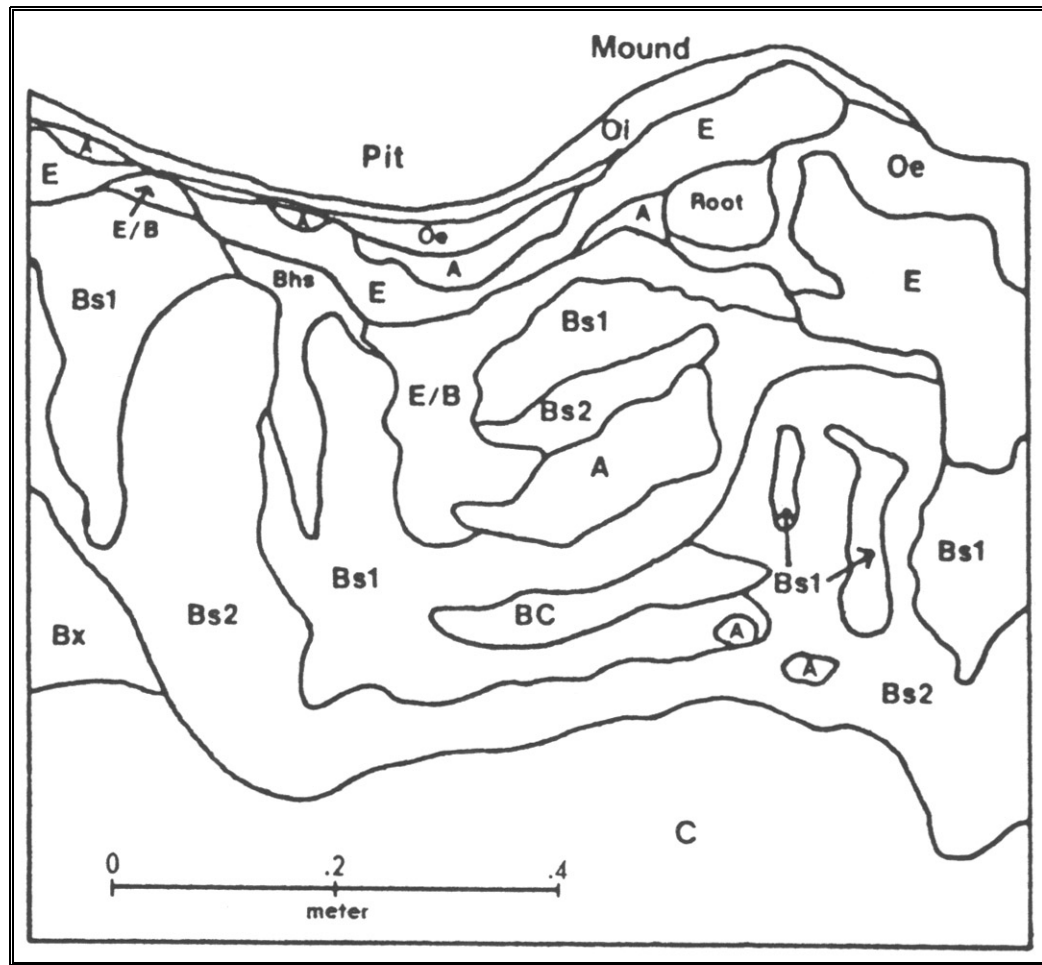


Figure 10.4 Pit/Mound Tree Fall Profile (Schaetzl 1986: Figure 3)

Bisection profiles of tree throw depressions and mounds have clearly demonstrated their internal stratigraphic complexity (Armson and Fessenden 1973; Denny and Goodlett 1956; Hall 1988; Johnson et al. 1987; Schaetzl 1986). Where disturbance extends into the B-horizon, mounds frequently consist of a core of B-horizon sediments with interspersed smaller clasts of A- and E-horizons, presumably due to the comparative thinness of the latter horizons (Lyford 1973; Lyford and MacLean 1966; Schaetzl 1986) (Figure 10.7). Karparchevskiy et al. (1968) found that in wet, organically rich soils, uprooting of shallowly rooted trees may lead to mounds composed exclusively of A- and O-horizon sediments. They also noted that E-horizons are most frequently discontinuous across pit-mound pairs, unless their formation post-dates the uprooting event (Karparchevskiy et al. 1968 in Schaetzl et al. 1990). E-horizon sediments often terminate at the edge of the pit (Lutz and Griswold 1939), but may continue beneath the adjacent mound (Schaetzl 1986). Mound sediments are often horizontally stratified, with lower B-horizon soils located proximal to the pit and upper horizon materials positioned on the distal side of the mound (Denny and Goodlett 1956).

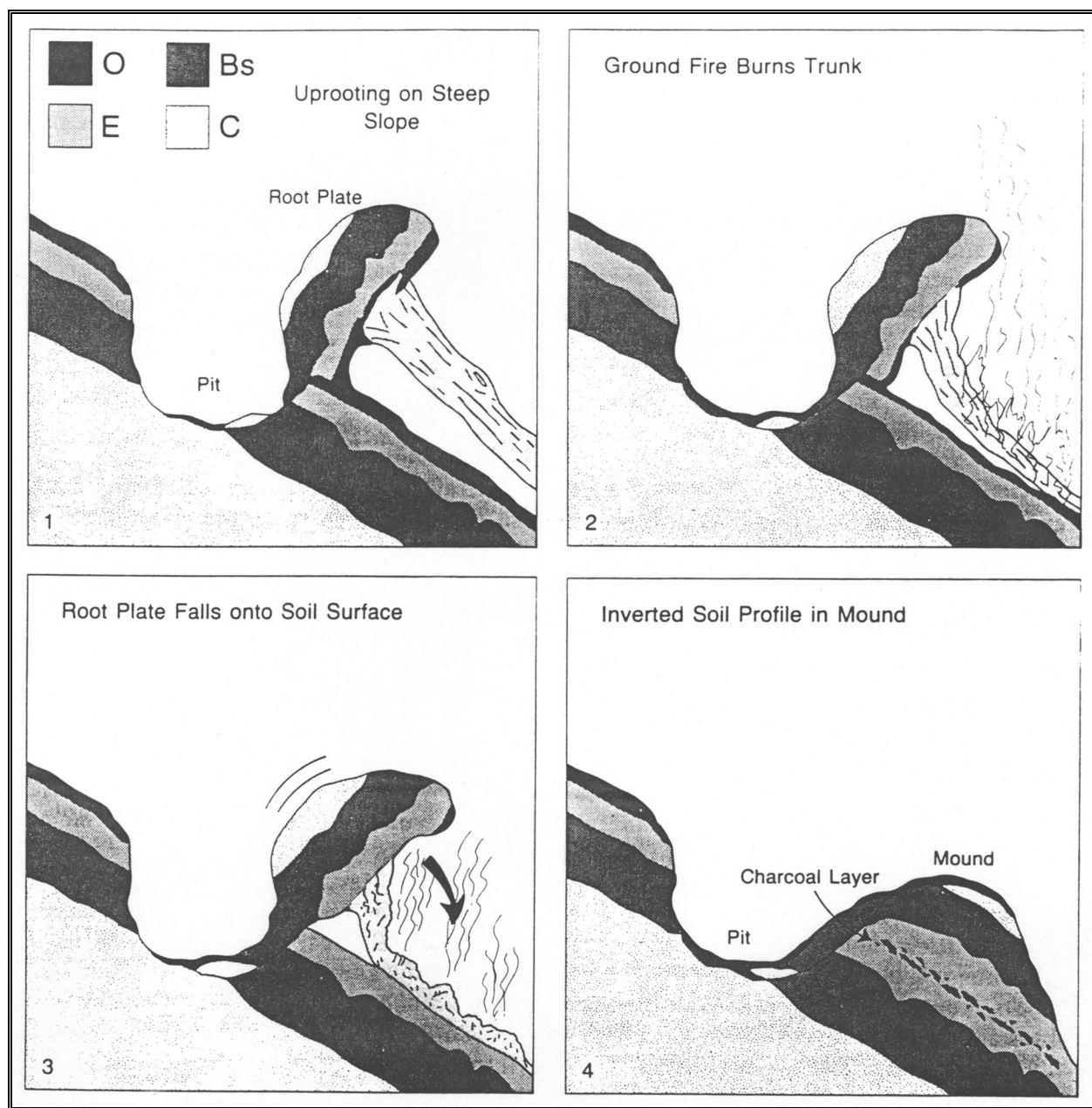


Figure 10.5 Complete Inversion Tree Fall Profile (Schaetzl and Follmer 1990: Figure 4)

Tree throw profiles are typically characterized by unusually thickened O-horizons due to litter accumulation within the pit (Armson and Fessenden 1973; Hall 1988). Studies of litter accumulation have found a mean litter thickness of 12 cm in pits, in contrast to a mean of 4.4 cm on mounds (Lyford and MacLean 1966). Infilling of pits by sediments from the root plate and mound may also cause thickened A-horizons within the pits, or buried organic horizons (Lutz 1940; Troedsson and Lyford 1973). Beatty and Stone (1986) found that soil moisture content and thickness of O-, A-, and E-horizons are typically greatest in pits and least within mounds, in contrast to undisturbed surrounding areas, which are intermediate in these characteristics.



Figure 10.6 "Armor/Lag" Deposit Tree Fall (Schaetzel et al. 1990: Figure 1)

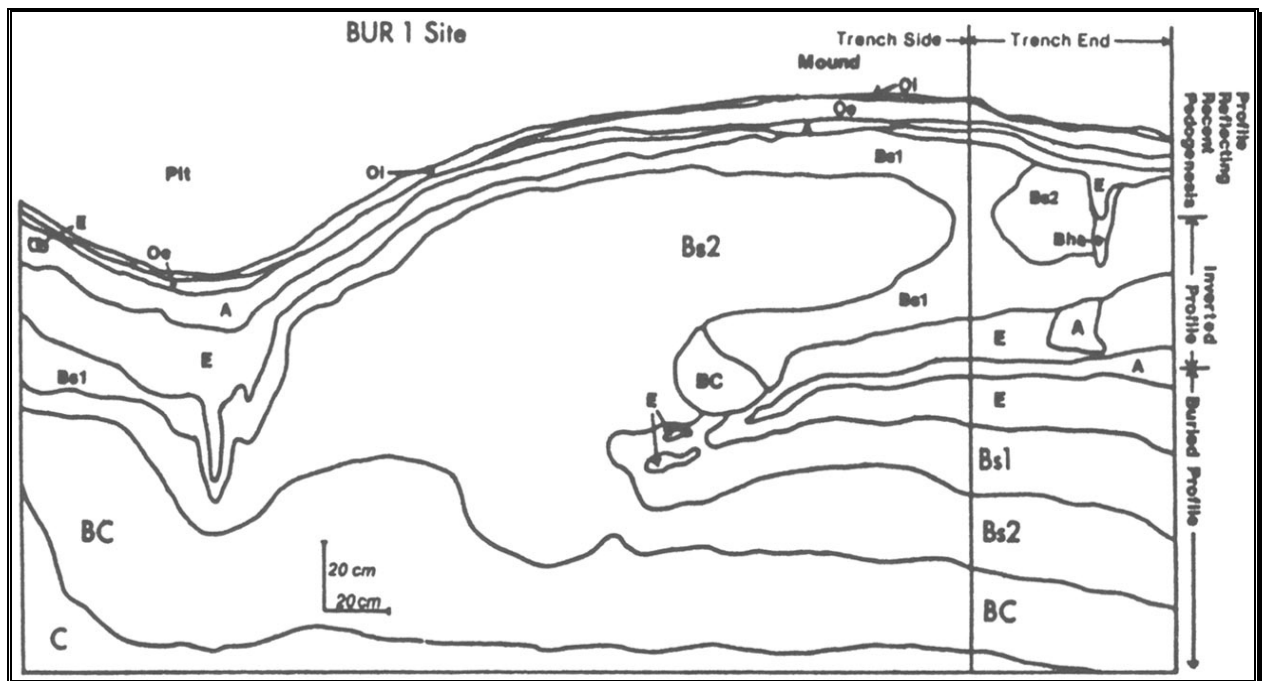


Figure 10.7 Tree Fall Mound Showing B-Horizon Core Sediments (Schaetzel 1986: Figure 2)

The primary influence of tree throws on pedogenesis occurs through the spatial redistribution of litter and soil moisture content, resulting in accelerated soil development beneath pits (Schaetzel et al. 1990). Frequently, in pits lying beneath trees that produce acidic litter, strongly developed podzolic soils with thickened E-horizons are found, suggesting concentrated leaching in these areas (Burns et al. 1984; Lutz 1940). In a study of Pennsylvania tree throws, Denny and Goodlett (1956) observed pit soils with thin, Podzol-like profiles, in contrast to a lack of recognizable stratigraphy within adjacent mounds. Upon finding well-developed Spodosols in pits and Inceptisols in mounds, Veneman et al. (1984) concluded that

precipitation flowing laterally through the O-horizon into the pits concentrated both water and organic acids within them. Description of tree throw pits over 500 years old, also containing well-developed Spodosol profiles with minimal soil development in adjacent mounds, suggest that rates of post-uprooting pedogenesis are least in mounds and greatest within pits (Schaetzl et al. 1990).

Soil characteristics, and thus classification, may also change as a result of past pedoturbation (e.g., the interrupted and cyclic horizon character of many Spodosols) (McKeague et al. 1969). Lutz and Griswold (1939) have suggested that interfingering of E- into B-horizons may result from the infilling of decaying root channels (Figure 10.8). E/B- and B/E-horizons, common to many forest soils, may therefore be the result of tree throws (Schaetzl et al. 1990). However, Veneman et al. (1984) concluded that, despite the fact that 25 percent of the surface in their study area in Massachusetts was characterized by pit-mound topography, only 6 percent of those soils had been changed taxonomically by uprooting events.

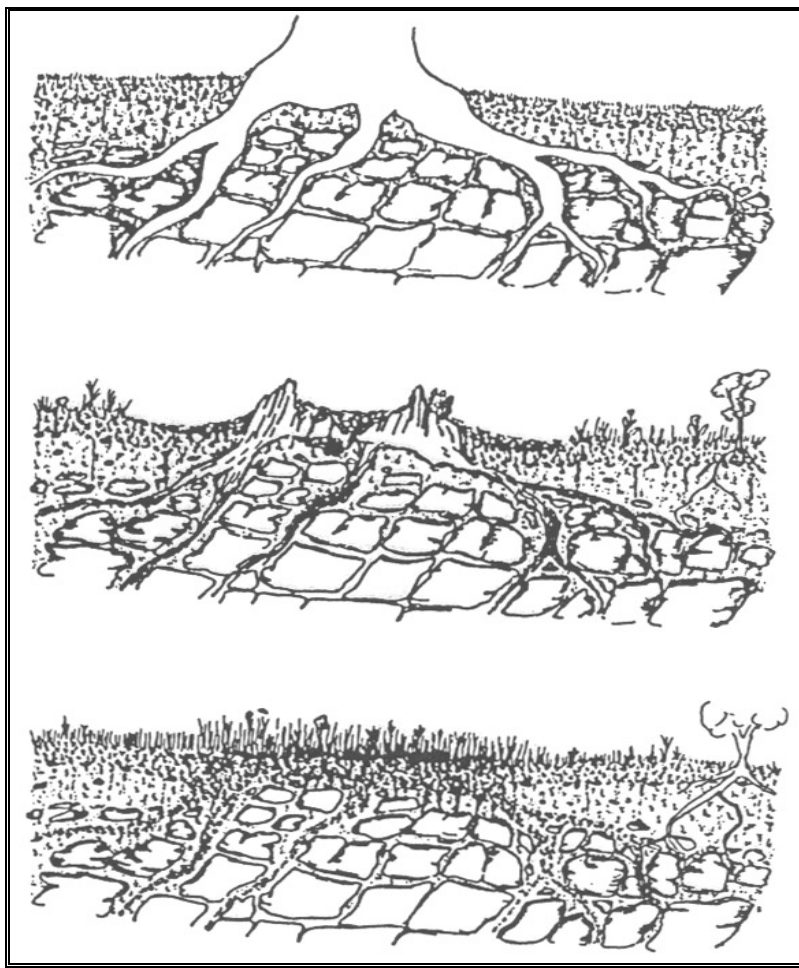


Figure 10.8 Infilling of Decaying Root Channels (Lutz and Griswold 1939)

Tree throws may be difficult to detect in certain conditions (Langohr 1993). These conditions include areas with loose and fragmented earth (i.e., usually characterized by trees with very shallow rooting systems or trees on slopes); older tree throws with little or no traces of the soil horizons; tree throws in areas where the soil had weakly developed stratigraphy prior to the

throw; and intense pedogenetic processes immediately after tree throw (e.g., bioturbation by worms and larger burrowing animals). Artifact distributions have been used as tree throw indicators, when soil conditions (i.e., sandy soils) are inconclusive (Crombe' 1993). In the case of a northern Belgium study, the general time frame of the tree throw occurrence was identifiable through the presence or absence of Mesolithic artifacts. The cultural occupations of the site occurred prior to most of the tree throws. The artifact distributions in these tree throws concentrated on the leeward side of the throw (Crombe' 1993).

Studies of the longevity of pit/mound pairs have involved the use of several different methods of age estimation and are usually based upon one or more of the following types of evidence: (1) relation of the pit/mound pair to a known natural disaster (i.e., tornado, hurricane, or volcanic eruption) in the area (Held and Bryant 1989, in Schaetzl et al. 1990); (2) soil development within pits in combination with careful study of pit/mound morphology (Denny and Goodlett 1956; Lyford and MacLean 1966); (3) dendrochronologic age estimates of trees growing on mounds or within pits (Veneman et al. 1984); (4) estimation of increased tree growth surrounding pit/mound pairs (Foster and Reiners 1986 in Schaetzl et al. 1990; Henry and Swan 1974); (5) measurement of infilling and root-plate deterioration processes (Small 1987); and more recently (6) radiocarbon dating methods applied to organic materials buried within pits (Schaetzl and Follmer 1990).

Estimates of pit/mound longevity vary greatly, frequently due to regional differences in climate, sediment characteristics, and area of initial disturbance. In humid, tropical environments, the rate of infilling can be extremely rapid, removing all traces of original pit/mound microtopography within five to ten years (Putz 1983). At the other extreme, studies of sandy mounds in Michigan suggested they were approximately 2400 years old based on C14 evidence (Schaetzl and Follmer 1990). This estimate stands in sharp contrast to those produced by alternate methods applied to these same mounds, which suggested a mean age of 500 years or less (Beatty and Stone 1986; Swanson et al. 1982). Regardless of the methods used in age determination, Schaetzl et al. (1990) caution that age estimates of extant mounds do not necessarily represent maximum longevity, primarily due to environmental and other factors involved in their degradation.

SUBSURFACE TREE MORPHOLOGY STUDY

Despite the on-going controversy surrounding the excavation and interpretation of these subsurface anomalies, few archaeologically-oriented studies of tree throws have been conducted in Delaware and surrounding areas (Mueller and Cavallo 1995; Thomas 1982; Thomas and Payne 1981). In order to aid in the interpretation of the range of environmental and cultural processes that have led to the complex archaeological patterning within the State of Delaware, an experimental subsurface tree morphology study was undertaken in conjunction with excavations at Hickory Bluff. This study was conducted on-site to provide a data set that would be comparable to excavated features encountered during concurrent archaeological investigation.

Hickory Bluff provides a unique opportunity to investigate the tree throw hypothesis. The western half of the site was unplowed, and tree disturbances in that area had likely retained much of their original configurations. The area was vegetated in mature forest, the tree species likely representative of those occurring on site during the later half of the Holocene. Previous and ongoing work at Hickory Bluff provided ample evidence for the presence of large basin

features on site. This allowed for a direct comparison of subsurface configuration of trees with archaeological basins identified within the same pedological and environmental contexts.

Methodology

Prior to the beginning of the investigation, a systematic survey of the entire project area was conducted in order to inventory all tree related ground disturbances potentially available for study. Depressions and hollows created by rotting tree stumps or tree throws and standing, decomposing tree stumps were included for consideration. Seventeen examples were chosen for investigation. The sample was chosen to incorporate a variety of tree sizes and different species. Tree stumps were measured 20 cm from the soil-stump boundary in order to determine size category. Size categories were small (<40 cm), medium (40-80 cm), and large (>80 cm). The majority of these specimens were located within the unplowed portion of the site, both on the terrace (bluff) top and its western slope. Examples within the eastern, plowed portion of the site were also included in order to provide comparative material for features in similar disturbed contexts. When extant wood was present, it was identified to species level, when possible, by archaeobotanist Justine Woodard McKnight.

Ground surface disturbances caused by the decomposition of stumps, or by tree throws, were first bisected to obtain a profile for direct comparison with bisected cultural features. The remainder of the ground surface disturbance was then removed using additional units. Standing, decaying stumps were simply bisected with a trench large enough, both horizontally and vertically, to determine the full extent and nature of the tree's sub-grade configuration.

Data collection methods were modeled on those used in the archaeological investigations in order to obtain comparable data sets. Excavation of tree throw depressions and decomposing stumps were conducted utilizing arbitrary 10-cm levels within visually discernible strata. All soil disturbed was removed as "feature fill," leaving the undisturbed surrounding soils in place. During the course of the excavation, a succession of planview maps was generated and extensive photo-documentation was undertaken. When the "feature fill" had been fully removed, final photographs were taken and contour maps of the resulting excavation were generated at appropriate (2.5-10 cm) intervals. Whenever archaeological features were encountered during experimental excavations, they were carefully recorded and removed according to site methodology, noting the impact of the tree's intrusion on the feature when possible. If the tree did not significantly disturb the cultural feature, the remainder of the tree was removed while leaving the feature in situ.

Each of the trees excavated at Hickory Bluff were separated into one of the following three categories: standing, partially decayed stumps, depressions caused by stumps completely decayed in situ, and tree throws. Standing, partially decayed stumps were chosen to constitute the majority of the study sample as these were shown to be the most common type of tree related ground disturbance on the site. The second category of tree related ground surface disturbance consisted of depressions left in areas in which the tree/stump had apparently fully rotted away. These were identified as roughly circular to ovoid depressions on the ground surface. Of the seventeen trees originally identified for bisection (BX), two were deleted from the study during early stages of their investigation. BX 11 was a slight surface depression about 10 cm deep and of unknown origin. BX 13 exhibited evidence of recent soil disturbance and inclusions of modern debris. Both disturbances were deemed not to represent tree locations and were deleted

from the study sample. A single tree bisection, designated BX 18, was added to the study in conjunction with analysis of the archaeological excavations. The BX 18 designation was applied to a large, living oak tree that had been sectioned by an archaeological block excavation.

In addition to archaeologically documenting tree related disturbances at Hickory Bluff, other observations were incorporated into the study. These included: three tree throws at the Puncheon Run Site located on the west side of the St. Jones River, across from Hickory Bluff; the archaeological documentation of a tree throw at the Sandom Branch Site Complex (7NC-J-227/7NC-J-228), located about 18 miles north on a small tributary of Blackbird Creek; and monitoring of the tree and stump removal undertaken at Hickory Bluff subsequent to completion of archaeological excavation.

Standing or Partially Decayed Stumps

A total of nine stump features were investigated (BX 2, BX 4, BX 6, BX 9, BX 10, BX 12, BX 14, BX 15, BX 16).

BX 2

This was a small (25 cm) pine, probably in the yellow/hard pine group, that was bisected with two 1 m² units that removed the west half of the tree (Figure 10.9). The root mass remained intact with significant amounts of fresh wood present. In profile, the stump retained quite a bit of heartwood, indicating that the tree had not been dead for very long. The eastern profile displayed a broad central tap root with two smaller roots extending diagonally downward from its base. The tap root extended to a depth of 70 cm and measured approximately 10 cm across at its terminus. Soils immediately adjacent to the roots contained small, concreted bits of soil (1-3 cm), and a darkened, organically stained matrix was variably present around the outer edges of each root, extending no more than 1 cm in any direction. The A- and E-horizons remained intact, showing almost no evidence of intrusion, and all roots terminated just above the E/B-horizon transition.

BX 4

This large decomposing red oak stump (*Quercus* sp.) measured 90 x 120 cm. The west half of the stump was removed using two 100 x 80 cm units. The root mass was encountered at three relatively discrete horizontal levels, measuring 5 cm, 13 cm, and 28 cm below the current ground surface and reached a maximum horizontal diameter of 1.6 m (Figure 10.10). In profile, roots remained clearly defined by papery exterior shells filled with decayed organic root matter. The stump remnant penetrated into the subsoil on the north end of the excavation to a depth of 40 cm. The transition between the A- and E-horizons was heavily disturbed by root intrusion, resulting in soils with a high degree of mottling (>50 percent). The B-horizon was completely unaffected.



Figure 10.9 Tree Bisection BX 2



Figure 10.10 Tree Bisection BX 4

BX 6

This stain was approximately 50 cm in diameter, amorphous in shape, and was probably the remains of a cedar stump (Figure 10.11). It was bisected using a 1 x 3 m trench. A rodent hole and tunnel traveling toward the stump were visible at the surface. Large areas of root activity were mapped at the top of the plow zone and E-horizon. A large stain, 60 cm in size, at a different orientation, was mapped at the top of the reddish subsoil. This was excavated as part of the root ball, but in profile was viewed as a separate stain. The stump itself forced portions of the A-horizon into the underlying matrix with concreted soils in the vicinity of the wood. The total depth of this excavation was 72 cm.



Figure 10.11 Tree Bisection BX 6

BX 9

This stump was a small (25 cm) cherry (*Prunus serotina*) rotting on the surface. The west half of this stump was removed utilizing a 1 x 2.5 m trench. The root mass was completely decayed and was identified by dark organic staining that retained no traces of wood. Root stains radiated horizontally from the central root mass at natural soil transitions (Figure 10.12). The profile showed a roughly circular organic stain in the area of the decayed root mass that measured approximately 25 cm in diameter. The A-horizon soils had been dragged downward by root development and decay into the sediment below, creating a wide, shallow lens (10 cm deep and 1 m in diameter) of organic soil intruding into the upper portions of the E-horizon. B-horizon soils were not penetrated by the root mass. The entire excavation filled a wide, shallow depression that measured over a 1 m area and was excavated to a depth of 58 cm below datum (bd).

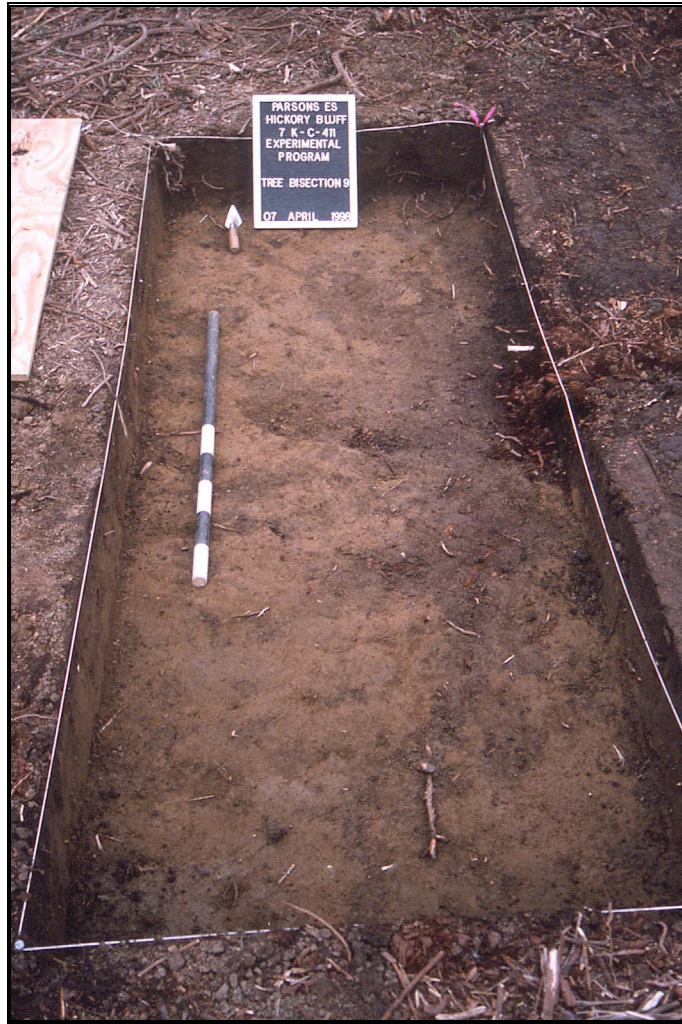


Figure 10.12 Tree Bisection BX 9

BX 10

This medium (40 cm) red oak stump (*Quercus* sp.) was located on the western slope of the landform (Figure 10.13). It was bisected using a 1 x 3 m trench to remove the northern half. Roots, which were partially decayed, radiated diagonally, vertically and horizontally from a central area measuring up to 1.5 m wide in profile. Disturbance to surrounding soils was minimal and localized around the main body of roots that had been anchored within A- and E-horizons. Minor areas of soil concretions were found immediately below the rotting stump and around larger decaying roots. Impact to B-horizon soils was not observed.



Figure 10.13 Tree Bisection BX 10

BX 12

This large (90 cm) red oak stump (*Quercus* sp.) was bisected using a 1 x 3 m trench that removed the southern half of the decaying stump and root-disturbed soils (Figure 10.14). In profile, the root disturbance occurred in a discrete area approximately 2.5 m wide. Impact to the E-horizon soils, however, appeared to be minimal. The presence of decayed roots was betrayed by diffuse organic staining seen at the upper portions of the E-horizon. Individual roots could be traced radiating outward from the central root mass beginning approximately 10 cm into E-horizon soils and decreasing in size and number with depth. B-horizon soils were penetrated by five individual roots resulting in a slight depression at the E/B-horizon interface. The root ball was bisected twice to determine if it possessed a taproot. None was recorded.

BX 14

This bisection was located about 8 m from the St. Jones River's edge in an area that had been impacted by a small historic borrow pit. A- and E-horizons were both depleted and very sandy. Subsoil consisted of sand with medium and small gravels. A large standing pine stump (probably in the yellow/hard pine group) was bisected along the east-west axis, utilizing a 1.75 x 2 m block (Figure 10.15). The stump measured approximately 80 cm across at ground surface and disturbed an area about 2 m in diameter with a depth of 78 cm bd. Although most root disturbance was restricted to a shallow, irregular shaped area around the stump, horizontal extensions of this disturbance into the surrounding subsoil were noted.



Figure 10.14 Tree Bisection BX 12



Figure 10.15 Tree Bisection BX 14

BX 15

This was a large (50 cm) partially decayed white oak stump (*Quercus* sp.) bisected on a north-south axis with a 1 x 2 m trench (Figure 10.16). Individual roots were largely intact (undecayed) and radiated both diagonally and vertically from the central core. The stump disturbed a subsurface area 1 m in diameter to a depth of 52 cm bd. A TAS cluster (Feature 162) was encountered in the northernmost unit approximately 15 cm below modern surface. Detailed maps were drawn and the feature was left in place in the northern half of the 1 m unit. Feature 163, a second TAS cluster was identified originating 5 cm below Feature 162. Both features were fully documented. Soil disturbance was minimal in all horizons, restricted to the 1-2 cm immediately surrounding each individual root. Several small roots (<3 cm in diameter) intruded into B-horizon soils, but disturbance surrounding each was less than 1 cm. The disruptive effect of the root growth on TAS placement and configuration was difficult to assess. However, based on the individual artifacts' vertical positions, translocation is not thought to have been extensive. In several instances, roots were observed growing around individual TAS artifacts rather than apparently having displaced them.



Figure 10.16 Tree Bisection BX 15

BX 16

This large (85 cm) partially decayed red oak stump (*Quercus* sp.) displayed characteristics of both standing stumps and tree throws (Figure 10.17). It had partially fallen before snapping, approximately 40 cm from its base. The tree trunk remained lying towards the east, beside the decaying stump. The base of the tree began to pivot on an east-west axis, bringing up a small mound of A- and E-horizon soils on the western side. In excavated (exposed) profile, the root mass remained clearly defined. Larger roots were present as papery outer husks filled with decayed root matter, whereas smaller ones were discernible only as organic soil

stains. While the partial tree throw appeared to have disrupted a portion of the underlying profile, the subsurface disruptive effects of the actual tree growth appears to have been minimal and restricted to localized organic staining around larger root masses. Soils beneath the central core of the root mass appeared extremely concreted. Two thermally altered stone (TAS) features were identified in this bisection. Features 182 and 189 were encountered approximately 15 cm below the surface near the top of the E-horizon and were separated by two large, relatively intact roots. The western and eastern units were bisected, leaving half of each feature in situ.

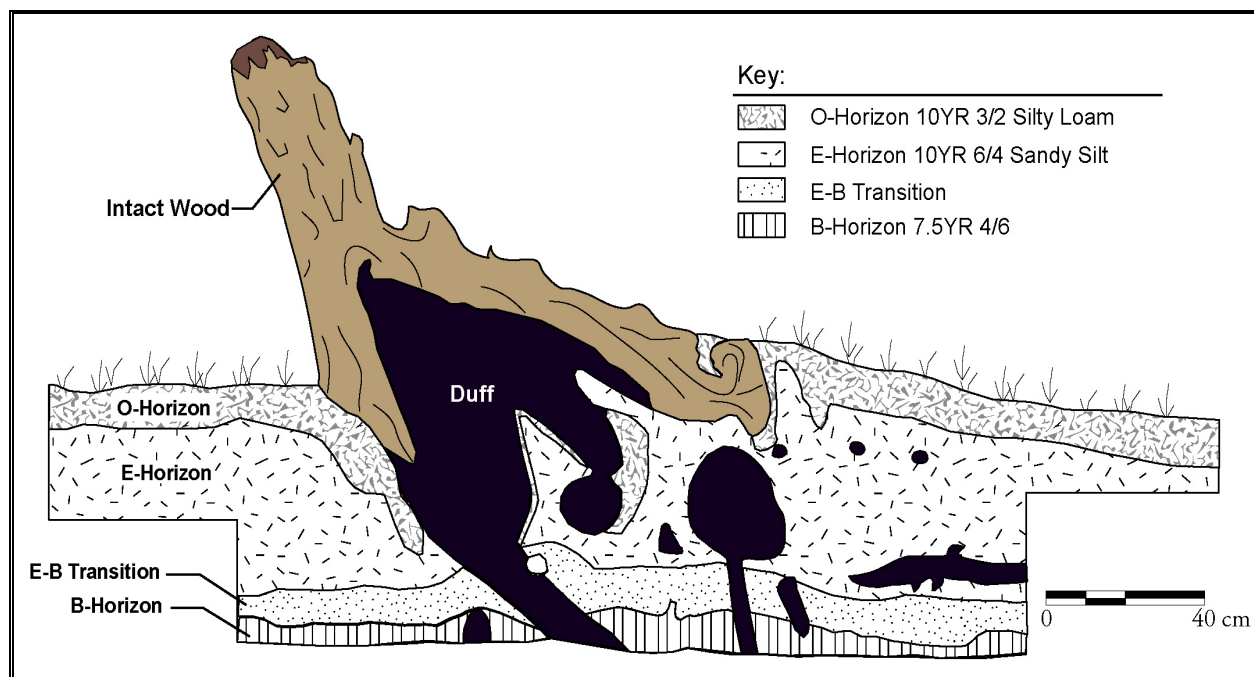


Figure 10.17 Hickory Bluff BX 16 Profile

Stump Depressions

Two tree depressions resulting from the decomposition of tree stumps were investigated (BX 1 and BX 8).

BX 1

This circular depression measured 1.3 m in diameter and 15 cm deep at the surface (Figure 10.18). The entire depression was removed using a 2 x 2 m block. The north half of the depression was removed first in order to obtain a bisection profile. A roughly circular, charcoal-flecked patch of A-horizon soils intruded into the E-horizon. This conformed closely in size, shape and location to the surface depression, and may have been caused by soil eroding into the void created by the decomposition of the tree stump and root ball. Except for the presence of charcoal flecking within A-horizon sediments, soils were homogenous and compacted. The area of intrusion was removed in 10 cm levels, resulting in a basin-shaped excavation approximately 1.15 m wide x 35 cm deep. The sides were relatively smooth, although some surface irregularities were noted. Following excavation of the charcoal-flecked A-horizon soils, the surrounding homogenous E-horizon matrix was removed. At the E/B-horizon transition, a

roughly circular disturbance was present, located almost directly below the surface depression. This area was filled with silty E-horizon sediments with a central core of mottled soils presumably pushed down by root growth. When disturbed sediments were removed, a roughly basin-shaped area (80 cm wide x 30 cm deep) remained. Irregularities and indentations, apparently voids left behind by the decomposition of the root system, punctuated the bottom and sides.



Figure 10.18 Hickory Bluff BX 1 Excavated Planview

BX 8

This circular depression was located at the western edge of the site on a modest slope associated with the bluff edge. The depression measured approximately 90 cm in diameter and was 12 cm deep from the surface (Figure 10.19). It was excavated within a 1 x 2 m block. The void apparently was created when the stump and root ball decomposed and subsequently filled in with compact, homogenous A-horizon soils. These soils interfaced with the underlying E-horizon, forming a conical shaped feature measuring 35 cm wide at the top and 30 cm deep. B-horizon soils did not appear to have been affected by the root system. Two large, completely rotted roots were located near the area of disturbance, but neither of these clearly emanated from the root ball area.



Figure 10.19 Tree Bisection BX 8

Tree Throws

The third group of tree related ground disturbances consisted of apparent tree throws, or depressions caused by the uprooting of trees, and included BX 3, BX 5, BX 7, and BX 17. BX 5 and BX 17 represented confirmed (obvious) tree throws, while BX 3 and BX 7 were suspected tree throws.

BX 5

The stump of the fallen tree with attached roots was still lying adjacent to a roughly circular, partially infilled depression where the stump pulled out of the ground (Figure 10.20). It was investigated using a 2 x 2 m block. The stump was approximately 20 cm in diameter at the base. The attached root mass and adhering uplifted sediments measured approximately 80 cm in diameter. The depression caused by uprooting measured approximately 90 x 110 cm and was more than 25 cm deep at the center. A-horizon development was almost nonexistent within the ground surface disturbance itself. When surrounding A-horizon soils were removed, an ovoid area of loosely packed mottled A- and E-horizon soils was visible within the compact, homogenous E-horizon surrounding the area of ground disturbance proper. The loose nature of soils and the paucity of organic buildup within the depression suggested that the downing of the tree was a fairly recent event. When mottled A- and E-horizon sediments were removed, the void remaining was basin-shaped and shallow, measuring approximately 1 m wide x 10-20 cm deep, with an uneven bottom contour. The B-horizon soils were not extensively penetrated by the root system and remained relatively unaffected by the downing of the tree. The entire excavation extended to 70 cm bd. Feature 92, a large irregular basin, was identified in unit N375 E662, subsequent to the removal of the extant tree disturbance.



Figure 10.20 BX 5 Stump and Depression

BX 17

This large (81 cm diameter) black cherry tree (*Prunus serotina*) was discovered lying approximately 6 m from the depression created as it fell (Figure 10.21). The ground surface disturbance caused by the uprooting of the tree was clearly visible approximately 6 m to the northwest, with two visible tire tracks on either side of the depression. The tree had most likely been uprooted mechanically, or pushed from its original position. A large portion of the root ball remained intact above ground at the base of the trunk. Some of the soils that had adhered to the root ball had sloughed to the ground, forming a 98 cm high x 2.5 m wide mound on the ground surface. The above ground portion was removed first, each unit individually, in order to obtain a profile view. Soils within both the mound and the depression were characterized by a high degree of soil mottling resulting from the mixing of soil horizons. Bisection of the mound revealed a somewhat ovate bottom contour that was very irregular, with one deep central section intruding into the B-horizon, positioned close to the fulcrum point of the tree throw.



Figure 10.21 BX 17 Stump and Depression

BX 3

This surface depression was ovoid in shape, measuring approximately 1.3 x 1 m, and 10 cm deep at the surface (Figure 10.22). It was investigated using a 1 x 2 m block. After the A-horizon was removed, an oval area was visible at the top of the E-horizon where organic debris had collected at the base of the ground surface disturbance. When this depression was bisected, the profile clearly showed horizontal banding of lighter soils within the darker, organic fill. After surrounding E-horizon sediments were removed, it was evident that E-horizon soils had been pushed down into the B-horizon in a localized area by growth of the root system. There was a central area of heavily mottled sediments within this depression. When these soils were removed, the resulting void was shallow, with an irregular outline and bottom contour due to root growth and disturbance. A TAS feature (Feature 83) was discovered at the A/E-horizon interface immediately to the east of the excavated ground surface disturbance.

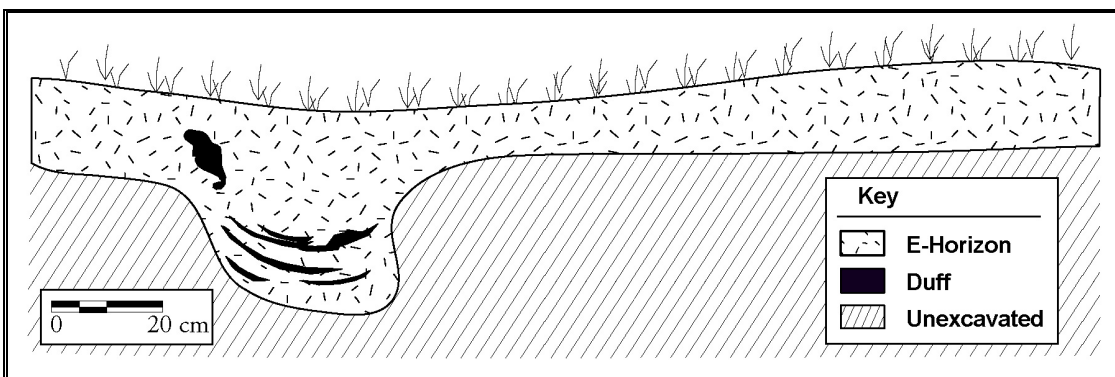


Figure 10.22 Hickory Bluff BX 3 Profile

BX 7

This shallow surface depression measured 110 x 80 cm across and 6 cm deep (Figure 10.23). It was investigated using a 1 x 2 m trench. Upon removal of the A-horizon soils, a roughly circular area of mottled A- and E-horizon soils containing a dense root mat was observed penetrating the surrounding E-horizon. Removal of these soils showed the ground surface disturbance to have a deeply rounded profile. The greatest density of the fine root mat was located at the base of this depression. After removal of the undisturbed E-horizon, it became apparent that some E-horizon soils had been introduced into the underlying B-horizon sediments. Removal of the intrusive E-horizon matrix produced a deep basin that mimicked the above mottled intrusion. The outline and bottom contour of the basin were highly irregular. In profile, the disturbance was deep (50 cm) and steep sided, suggesting a large taproot.



Figure 10.23 Tree Bisection BX 7

Living Tree Bisection**BX 18**

A living tree was bisected during the course of an archaeological block excavation (Figure 10.24). The specimen was a young mature Black Oak (*Quercus velutina*) approximately 35 cm in diameter. The wall of the excavation unit neatly fell at the very edge of the tree's trunk mass. Observations of the exposed unit profile proved to be instructive in assessing the actual undisturbed below grade configuration of a living tree. The below ground mass was surprisingly limited even for mature trees possessing substantial trunk size (Figure 10.24). The trunk mass essentially terminated at about grade level (base of A-horizon). The trunk flared just above grade level at the points that major roots begin to extend outward. These larger root members extended horizontally just below the humus. A few individual roots were encountered during excavation, growing downward from the base of the trunk. However, when observed in two dimensions only

(profile view), areas as little as 20 cm directly below the tree appeared to be completely unaffected.



Figure 10.24 Hickory Bluff BX 18 Profile

Treethrow Observations at the Puncheon Run Site and Sandom Branch Site Complex

In addition to observations made on Hickory Bluff, three modern tree throws were documented at the Puncheon Run site. These tree throws were photographed, and planviews and profiles of the ground surface disturbances were recorded when possible. All trees were identified to genus or species.

The largest of the three downed trees at the Puncheon Run site was a fully mature yellow poplar (*Liriodendron tulipifera*) with a bifurcated trunk. It was uprooted in June 1998 during a severe storm that brought wind gusts up to 80 mph. The depression created by the uprooting event was D-shaped in plan and measured 4.5 x 2.3 m (Figure 10.25). Though the tree was far larger than any of those bisected at Hickory Bluff, the maximum depth of the ground surface disturbance was only 70 cm. A small tap root was noted near the center of the root mass, nearly obscured by attached sediments. The basal contour of the disturbance was irregular. As the event was quite recent, infilling processes had not redeposited significant amounts of sediment within the ground surface disturbance.



Figure 10.25 Puncheon Run Site Downed Tree

The second Puncheon Run tree throw was also a large yellow poplar (*Liriodendron tulipifera*). Some soil had sloughed into the ground surface disturbance but a significant portion of the displaced soil remained attached to the extant, above surface root mass (Figure 10.26). This ground surface disturbance had a very irregular planview outline and profile. Maximum dimension in plan was 6.0 m with minimum dimension recorded at 1.5 m. Maximum depth of the ground disturbance was noted as very shallow, although its exact extent was not recorded.



Figure 10.26 Puncheon Run Tree Throw #2

The third tree had fallen downslope into the St. Jones River, and only a portion of the root mass was visible (Figure 10.27). The tree throw was older, as much of the ground disturbance had been infilled by slopewash and other processes. A very shallow depression was still evident immediately adjacent to the existing root mass, but little sediment remained attached to those roots, apparently having mostly sloughed back into the ground disturbance/cradle.



Figure 10.27 Puncheon Run Tree Throw #3

Archaeological documentation of a recent tree throw also was undertaken at the Sandom Branch Site Complex (7NC-J-227/7NC-J-228), located north of Smyrna, New Castle County, Delaware. This tree throw was observed during excavations at the Sandom Branch Site Complex and it was determined that excavation of the units associated with the tree throw would be beneficial to the overall study. The tree throw was investigated using two 1 x 1 m units that bisected the ground disturbance on a north/south axis. The specimen was a mature red oak (*Quercus* sp.) that had recently fallen. It appeared to have been alive when it fell, as evidenced by the presence of withered leaves on the branches. The upturned root ball measured approximately 2 m in diameter (Figure 10.28). The ground disturbance was D-shaped and was 10 to 15 cm deep. The water table was within 50 cm of the surface and did not allow for complete excavation of the units. The soil was a loose sandy loam and was saturated.



Figure 10.28 Sandom Branch Tree Throw

Monitoring Observations

Parsons staff were present during tree removal from Hickory Bluff at the start of project construction (Figure 10.29 and Figure 10.30). A large track hoe was employed to excavate and remove cut stumps. This allowed for the opportunistic examination of the below ground configuration of a large portion of the mature tree specimens that had been standing on Hickory Bluff. The major radiating near-surface segments were severed by the track hoe blade and left in situ. When the tree was removed from the ground, an extensive system of fine diameter roots was observed remaining attached to the main body of the stump. The majority of these were less than one inch in diameter. These small diameter roots comprise major portions of a tree's root system and are critical for both anchorage and transporting water and nutrients (Figure 10.30). In the event of a tree throw, these roots were typically observed to shear off near the base of the stump. Such root systems, left in place, either after being severed during a tree throw or after a tree naturally dies, are likely to simply degrade without leaving any appreciable physical traces.

Summary of Findings

The Subsurface Tree Morphology Study at Hickory Bluff provided several important insights. Perhaps the most salient of these was the documentation of how little actual below grade mass even a large tree possesses relative to its overall size. This understanding has considerable implications both for the preservation of near surface archaeological contexts and basin feature formation. The limited physical extent of the below grade tree configuration is borne out by a variety of observations. Stump crater excavation repeatedly suggested that extensive root disturbances associated with a tree location were relatively shallow. With the exception of individual tap roots, disruptions of the soil profiles were rarely seen to penetrate the E/B-horizon interface, which typically lay at a depth of 40 to 50 cm below surface. Documentation of tree throw morphology also appeared to demonstrate that the major components of the tree root systems extended outwards just under the surface. This observation was evidenced by the shallow form of the tree throw related ground disturbances documented at Hickory Bluff, the Puncheon Run site and the Sandom Branch Site Complex. The same phenomenon was demonstrated by the profile of the live tree, BX 18.



Figure 10.29 Tree Stump Removal at Hickory Bluff Illustrating the Root Ball



Figure 10.30 Tree Stump Removal at Hickory Bluff Showing the Fine Diameter Roots

EXPERIMENTAL FEATURE DEGRADATION STUDY

Both cultural and natural forces work in concert to form and shape the archaeological record. Despite the critical importance of these interactions, most archaeologists have fairly coarse conceptual understanding of the sequence of events and changes that occur as a ground surface disturbance is transformed into an archaeological entity. The experimental feature degradation study was initiated to observe and document how a variety of feature morphologies degrade and infill through time, and how these processes may lead to particular archaeological patterning. Eight experimental features (XF) were excavated in February 1998 on the southern periphery of Hickory Bluff. These experimental features were constructed in forms replicating archaeologically documented feature types. Changes to the features and the conditions under which these changes occurred, were carefully monitored and recorded. The observational study reported herein was conducted from February 1998 through April 2001. The experiments remain available for future study.

Methodology

The experimental excavations were constructed along a partially cleared east-west strip along the southern periphery of the Hickory Bluff project area (Figure 10.31 and Figure 10.32). The experimental features were placed in a staggered pattern, approximately 4 m apart, to facilitate easy access in and around them (Figure 10.33). Permanent rebar datums were driven into the ground adjacent to the individual features and were used for recorded measurements (Figure 10.34).



Figure 10.31 Experimental Feature Degradation Study Area Prior to Excavation, Looking East



Figure 10.32 Experimental Feature Degradation Study Area Post-Excavation, Looking West

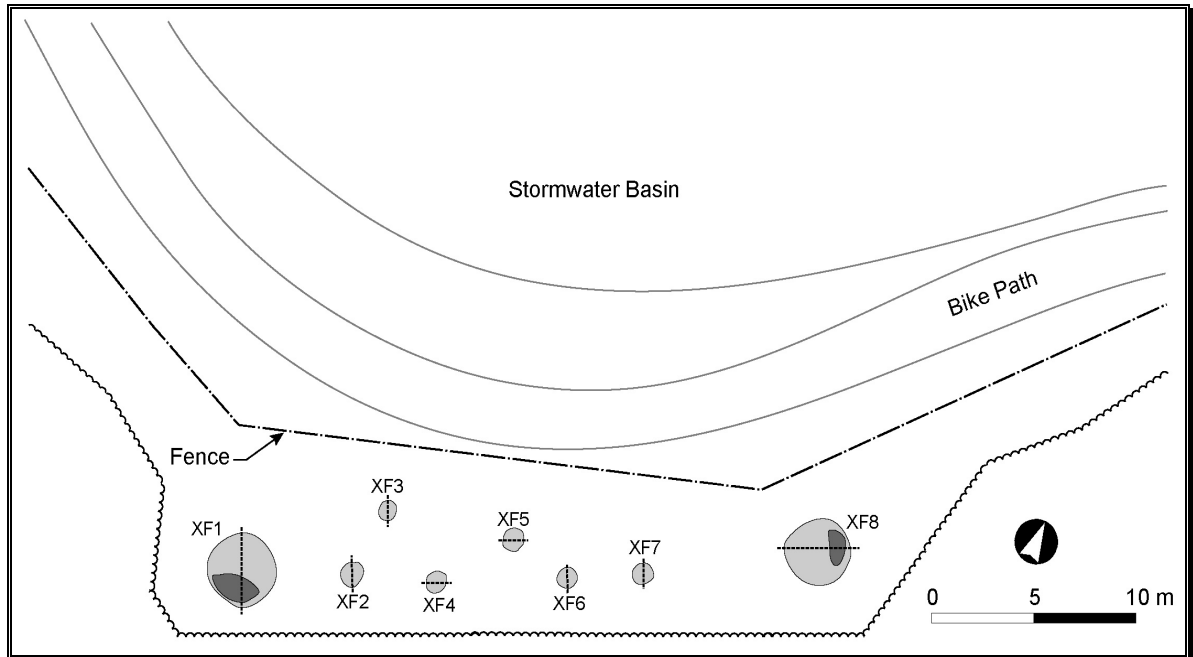


Figure 10.33 Experimental Feature Degradation Study Area Plan



Figure 10.34 Experimental Feature Degradation Study, Placing Datum at XF 8

The experimental excavations were designed to replicate archaeological feature types previously documented in Delaware. These entailed three morphological types: 1) large bi-level features replicating the pit house configuration (Custer and Silber 1995) typified by a very wide shallow portion or “living floor” with a steep-sided, flat-bottomed, D-shaped basin or “sub-basement” set in one end (Figure 10.35); 2) deep circular basins with conical profiles (Figure 10.36); and 3) circular basins with shallow bowl-like profiles (Figure 10.37) (Table 10.1). In all, two large bi-level features (XF 1 and 8), four deep conical features (XF 2 , 4, 5, and 6), and two shallow bowl-shaped features (XF 3 and 7) were constructed.



Figure 10.35 Large Bi-level Feature XF 1

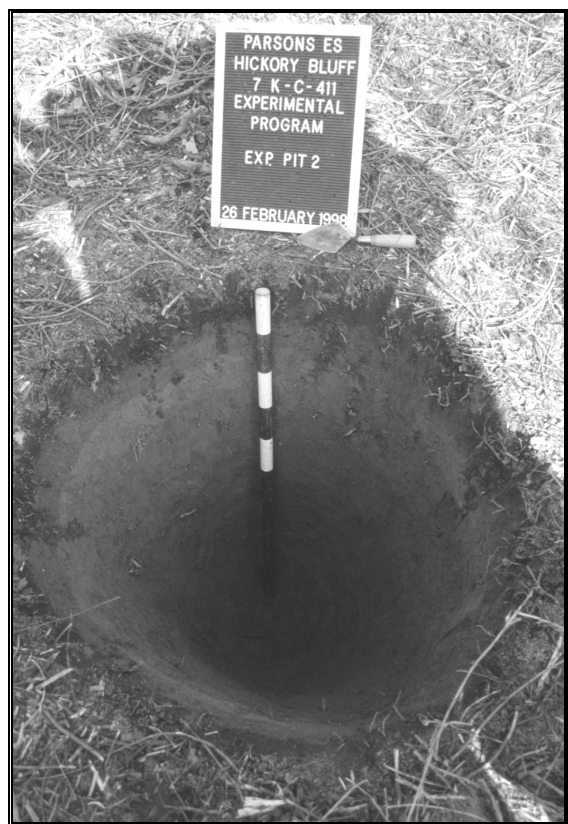


Figure 10.36 Deep Circular Basin XF 2



Figure 10.37 Shallow Bowl-shaped Basin XF 7

Specific variables were applied to the experiments (Table 10.1). These entailed, purposeful back filling of the features versus being left open, and the removal of excavated soils from the area as opposed to the soil being placed near the feature orifice. Six experimental

features (XF 1-3, XF 6-8) were left open and two features (XF 4 and XF 5), both deep circular basins, were immediately backfilled. Experimental features XF 1, XF 2, and XF 3 had the excavated soil removed from the feature area, while XF 6, XF 7, and XF 8 had the soil left in situ. The five westernmost pits (XF 1 through XF 5) were located in an area subjected to almost continuous sunlight during the course of the day, while the three eastern features were situated in a much more shaded environment.

Soils and soil conditions within the experimental area essentially mirrored those described for the archaeological site (Section 6.0). The experimental area had been plowed during modern or recent historical times. The area had been fallow for some time and had partially reverted to a young forest, resulting in the development of a thin forest humus overlying the plow zone. Soils were uniformly sandy (loamy sand) with an E-, BE-, B-horizon sequence present below the plow zone (Ap-horizon). Columbia Formation (Fm.) sands and gravels (C-horizon) comprised the basal stratum. These Columbia Fm. deposits were noted lying closer to the surface at the eastern end of the experimental location than at the western end.

Both qualitative and quantitative observations were recorded for the eight experimental features. Qualitative observations focused on four areas: geomorphology (wall collapses and slumping), hydrology (standing water, ice), floral intrusion, and faunal intrusion (animal burrowing and entrapment). Weather observations were also recorded as part of the study. At monthly intervals, the depths of the experimental features were recorded utilizing the permanent datum points. Photographic documentation provided sound visual evidence of the depositional changes and was employed minimally on a weekly basis. From February 27 through September 14, 1998, observations were recorded for every weekday, weather permitting. Daily observations were undertaken in the beginning of the study to document what was postulated to be the most dynamic period of degradation, prior to the establishment of vegetation that would stabilize the soils. From September 1998 through December 1999, observations were made on a monthly basis. Additional observations were recorded sporadically from December 1999 to April 2001. Figure 10.31 and Figure 10.32 depict the area at the beginning of this study. Figure 10.38 represents the study in progress and Figure 10.39 is near the end of the period of observation.

Table 10.1 Experimental Feature Parameters

Feature Number	Feature Morphology	Feature Size (m)	Depth (m)	Aspect	Backdirt Status	Backfill Status
XF 1	Large shallow basin w/D-shaped flat bottomed basin on end	3.12 x 2.80 1.88 x 1.12	0.10 1.00	Exposed	Removed	Open
XF 2	Circular w/deep conical base	1.00	0.97	Exposed	Removed	Open
XF 3	Circular w/ shallow rounded base	0.90	0.42	Exposed	Removed	Open
XF 4	Circular w/deep conical base	1.00	1.00	Exposed	N/A	Filled
XF 5	Circular w/deep conical base	1.00	1.00	Exposed	N/A	Filled
XF 6	Circular w/deep conical base	1.00	1.17	Shaded	In situ	Open
XF 7	Circular w/shallow rounded base	0.90	0.37	Shaded	In situ	Open
XF 8	Large shallow basin w/D-shaped conical basin on end	3.16 x 2.24 1.44 x 1.28	0.16 0.73	Shaded	In situ	Open



Figure 10.38 Experimental Feature Degradation Study in Progress, 1998

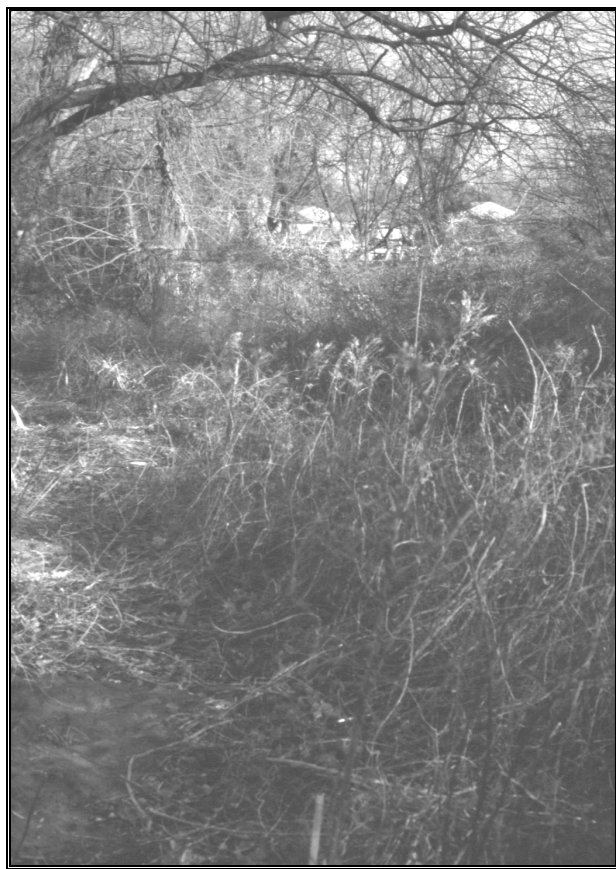


Figure 10.39 Experimental Feature Degradation Study In Progress, 2000, Looking East

In addition to local weather observations recorded on site, temperature, precipitation, and storm event data were collected from the State of Delaware. Daily temperature and precipitation information was compiled for the 1998 portion of this study. Temperature readings for Dover were obtained from the webpage of the Delaware State Climatologist (www.udel.edu/leathers/dov9198). Daily precipitation for Dover was derived from *Climatological Data, Maryland and Delaware* published by the National Climatic Data Center, Ashville, North Carolina. Specific storm events that occurred during this period in Kent County, Delaware were obtained from the National Climatic Data Center webpage (www4.ncdc.noaa.gov/cgiwin/wwcgi.dll?wwevent~storms). Specific peaks in the precipitation data were compared with known storm events and local observation of weather conditions. Freeze/thaw cycles may be implied from the 1998 temperatures recorded for this portion of the study. Only 32 days from February through December 1998 exhibited a daily minimum temperature of 32 degrees or lower (Figure 10.40). Only three days in that time frame had daily maximum temperatures of 32 degrees or lower. Precipitation peaks provided evidence of amount of rainfall and when compared with storm data, indicated the intensity of rainfall (Figure 10.41).

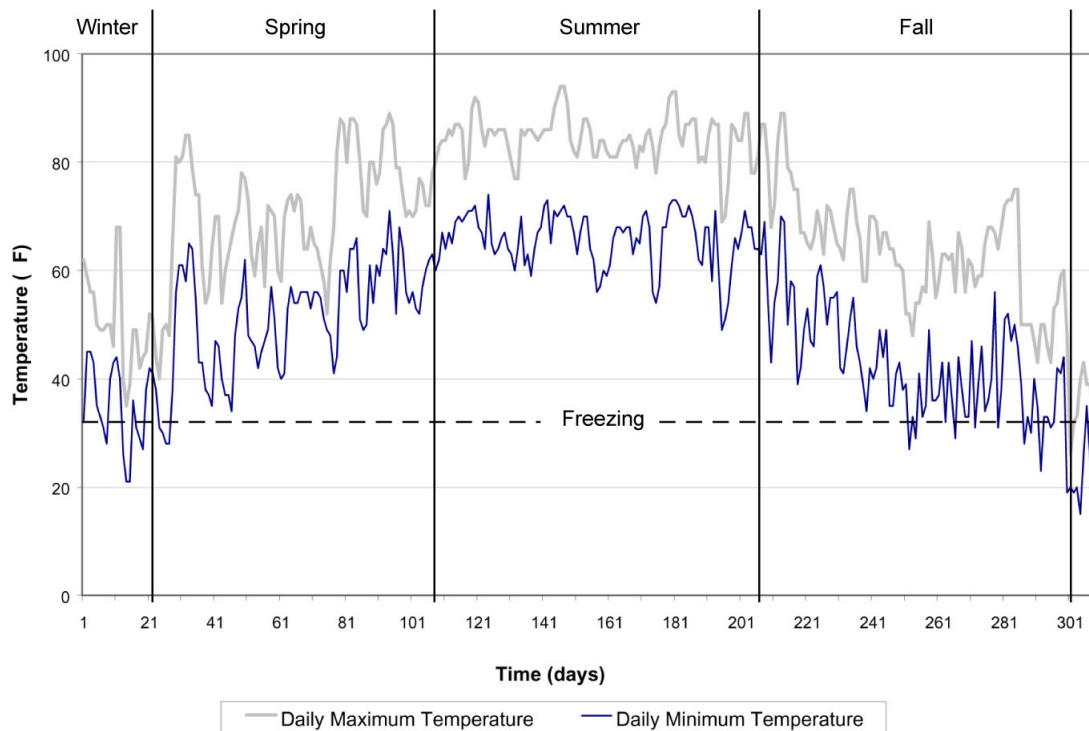


Figure 10.40 Daily Temperature 1998

Experimental Feature Chronology

The general chronology of feature degradation is summarized below for each experimental feature. Detailed observations by date and category are located in Appendix E.

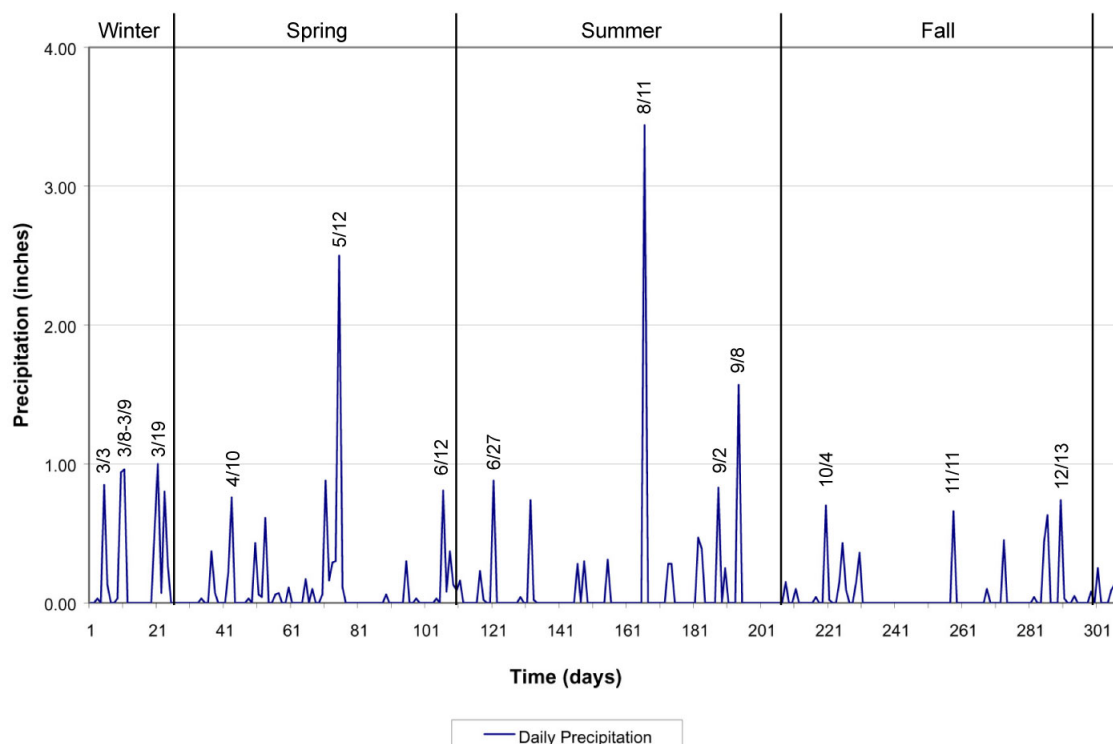


Figure 10.41 Daily Precipitation 1998

XF 1

XF 1 was a bi-level feature replicating the pit house configuration proposed by Custer and Silber (1995). It consisted of a shallow steep-sided, flat-bottomed “basement” or “living floor” area that measured 3.12 m at greatest dimension. A steep-sided, flat-bottomed, D-shaped basin or “sub-basement” was set in one end of the larger feature. This basin measured 1.00 m deep by 1.88 m wide and was excavated into sandy subsoil. The upper level or “living floor” area of this feature was excavated to a depth of 0.10 m and the area was thoroughly trampled after excavation in an attempt to simulate a limited daily usage. The backdirt was removed from the area around XF 1. This feature was located at the western end of the experimental area and was exposed to almost constant sunlight during the course of the day.

Within the first few days after excavation, leaves and small sticks had collected in the feature and worm activity was observed. The bioturbation in XF 1 was concentrated along the edges of the “sub-basement” walls. Less than a week after construction, earthworms tunneling into the floor had created a linear mound of backdirt approximately 15 cm long, 5 cm wide, and 1.5 cm high. Moderately heavy rain left standing water in the deeper “sub-basement” portion of XF 1. In mid March, worm activity decreased, apparently as a result of a series of freezes. The formation of spike ice crystals and resulting minor frost heaving was also observed at this time. This frost action apparently resulted in the observable accumulation of sediments at the base of the “sub-basement.” Late March brought a period of rain and a steady infilling of the basins, especially the deeper “sub-basement” portion.

By early April 1998, minor soil slumps were occurring with frequency in the lower portions of XF 1, especially in the “sub-basement” area. This process appeared to be enhanced by soil desiccation and perhaps ongoing earthworm activity. Significant rains occurred in April and the side walls and edges of the basins began to erode in earnest. Small pebbles were washing out of the walls of both of the basins and the side walls were becoming uneven and craggy. At the same time, a large variety of weeds were beginning to take hold in the feature. Progressive vegetative growth was observed later in the spring. This growth appeared to anchor much of the unconsolidated soil in and around the feature. The vegetation itself tended to begin growing more readily on the southern facing portions of the feature, apparently due to greater solar exposure. A sapling was observed growing from the sub-basement in the Spring of 2000, which reached a height of over 2.00 m by the end of the observations.

Earthworms were not the only fauna that appeared to contribute to the degradation of XF 1. A toad was observed in mid-April and it dug a burrow in the bottom of the pit. It disappeared by the first week of May and it is unknown whether it jumped out or was killed and eaten by a predator. A bullfrog was briefly trapped in XF 1, but escaped during observation. In mid May 1998, beehive entrances were constructed, creating holes near the upper edge of the XF 1 “sub-basement” and resulting in small mounds of B-horizon soil in the bottom of the basin. Flies were also observed on the bodies of decaying earthworms in the bottoms of both pits and were likely laying eggs there.

Measurements of depth were taken at two different locations in the XF 1 “sub-basement:” the east end and the center. Incremental filling of the excavation was noted throughout the study (Figure 10.42). Two distinct filling episodes were recorded for August of 1998 and in September 1999. The August 1998 increase was likely the result of a series of heavy thunderstorm rains that occurred during that time. The September 1999 accumulation can be directly attributed to the Hurricane Floyd event (9/16/99).

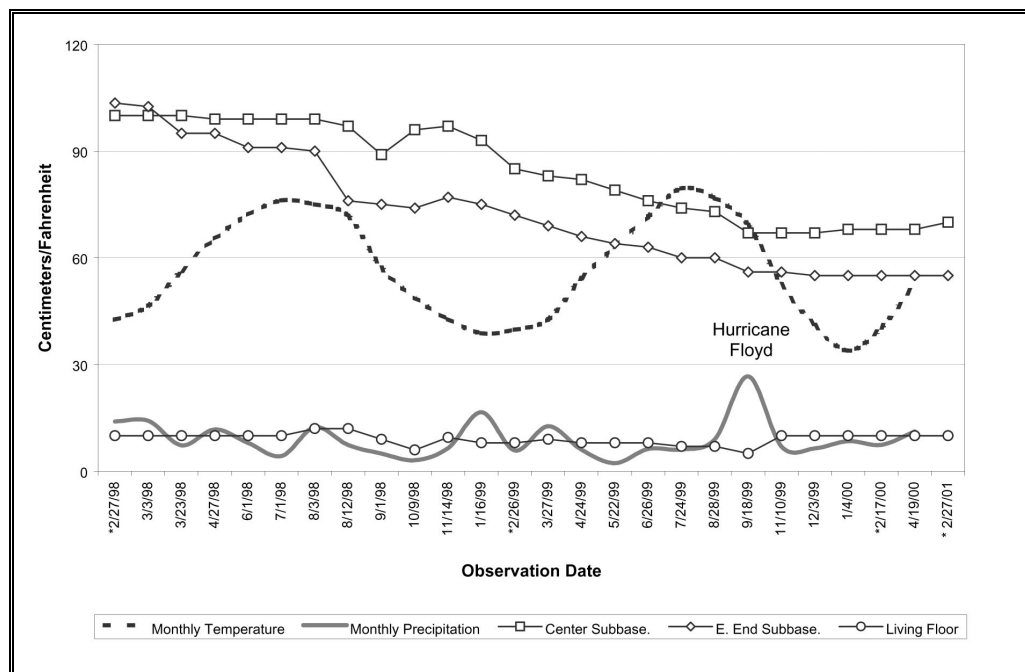
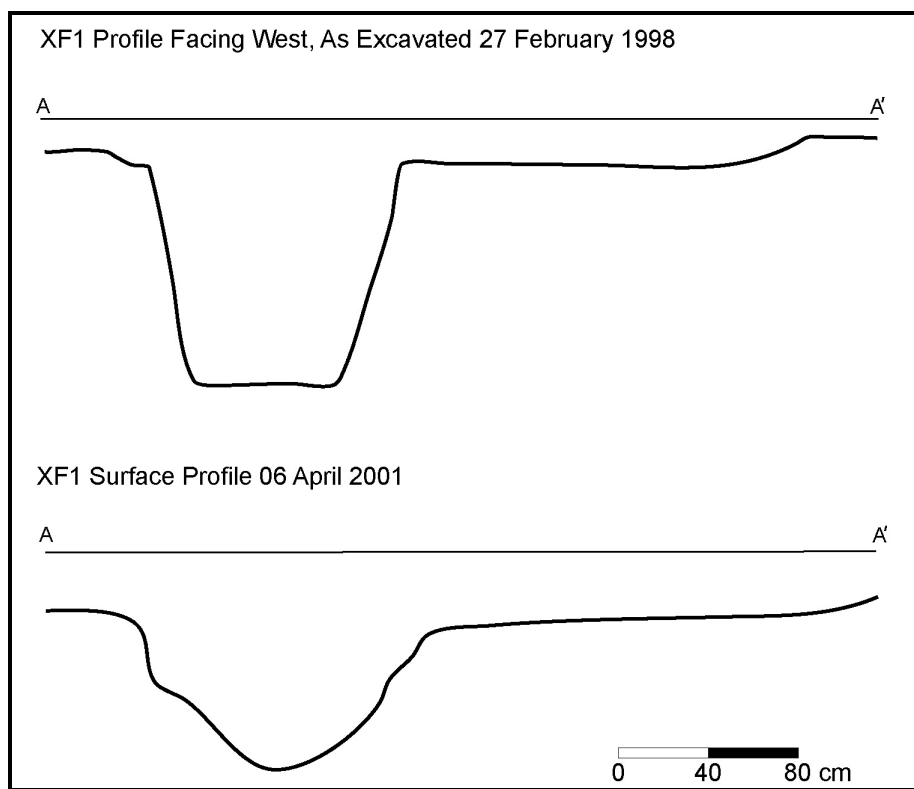


Figure 10.42 Rate of Infilling Compared to Monthly Precipitation and Temperature for XF 1

At the close of the three-year observation period, XF 1 was profiled for comparison with the original profile documentation (Figure 10.43). The comparison of the two morphologies indicated the degree of slumping and infilling noted since excavation and illustrated how the feature shape became less regular and more smoothed. The sharp cuts and planes evident in the initial excavation were weathered and the once steeply sloping walls were more gradually tapered to a rounded, instead of flat, bottom.



**Figure 10.43 Morphological Comparisons for XF 1
over the Course of the Observation Period**

XF 2

XF 2 was a deep circular basin measuring 1.00 m by 0.97 m deep. The feature was excavated to a depth at which it penetrated the Columbia Fm. sub-strata. The backdirt was removed from the immediate area of XF 2.

Marked changes began to occur within a week of construction. Rains began smoothing and rounding the sides and edges of the feature. Soils displaced in this manner began notably collecting at the bottom of the feature together with assorted organic detritus. Earthworms began tunneling throughout A- and E-horizons and within two weeks and were well established in the bottom of the feature as well. The first slump in XF 2 walls occurred the first week of April 1998.

Freezing weather in mid-March caused areas of ice to form in the upper half of XF 2 where ground water had perked out of the feature walls. This ice loosened soils, which washed into the feature bottom during ensuing rains. Periodic rains during March inundated the

excavations, aiding the influx of soil and organic debris into the feature. Ongoing minor erosion of the walls was noted along the vertical extent of the feature. The frequent rains kept the feature walls soft and moist causing minor slumping and facilitating worm action. Vegetation began to grow around the rims of the feature by the first week of April and, within another two weeks, was growing out of the upper side walls. A larger pebble (6 x 4 cm) fell out of the wall in XF 2 at the end of April, after it had apparently been partially exposed by earthworm activity. A total of seven centimeters of infilling occurred in the first two months.

Faunal activity included the presence of earthworms, insects, and toads. A toad was recorded in XF 2 at the end of April and remained there through observations made on May 21, 1998. It may have been subsisting on earthworms and likely consumed a beetle that had also been entrapped for a time.

A significant amount of infilling of XF 2 occurred over the three-year observation period (Figure 10.44). The original depth of 0.97 m was reduced to 0.59 m as a result of accumulation of soil at the base of the feature.

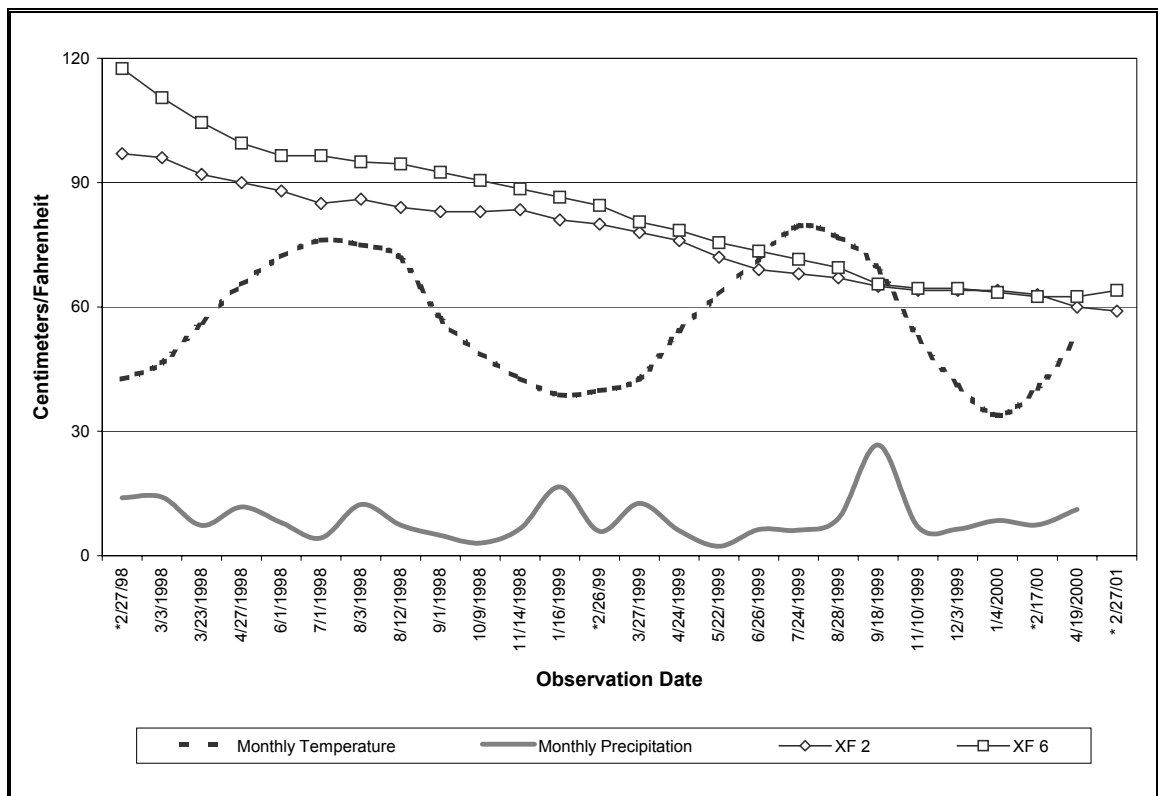


Figure 10.44 Rate of Infilling Compared to Monthly Precipitation and Temperature for XF 2 and XF 6

Comparison of the initial excavation profile and the profile recorded after three years of observation illustrated significant changes in the morphology of XF 2 (Figure 10.45a). The steep walls and conical shape weathered and became more undulated on one side and gradually tapering on the other. The increased slumping in the southern half (northern exposure) may be the result of less direct exposure to the sun allowing moss to form along the rim of the feature. The moss growth stabilized the soil on the rim, whereas the less stable walls of the feature began

to undercut causing the undulated morphology. The pointed base was smoothed to a rounded bottom and slumping was evident for the surface adjacent to the orifice. The resultant slumping gave the feature a much wider appearance than the initial excavation.

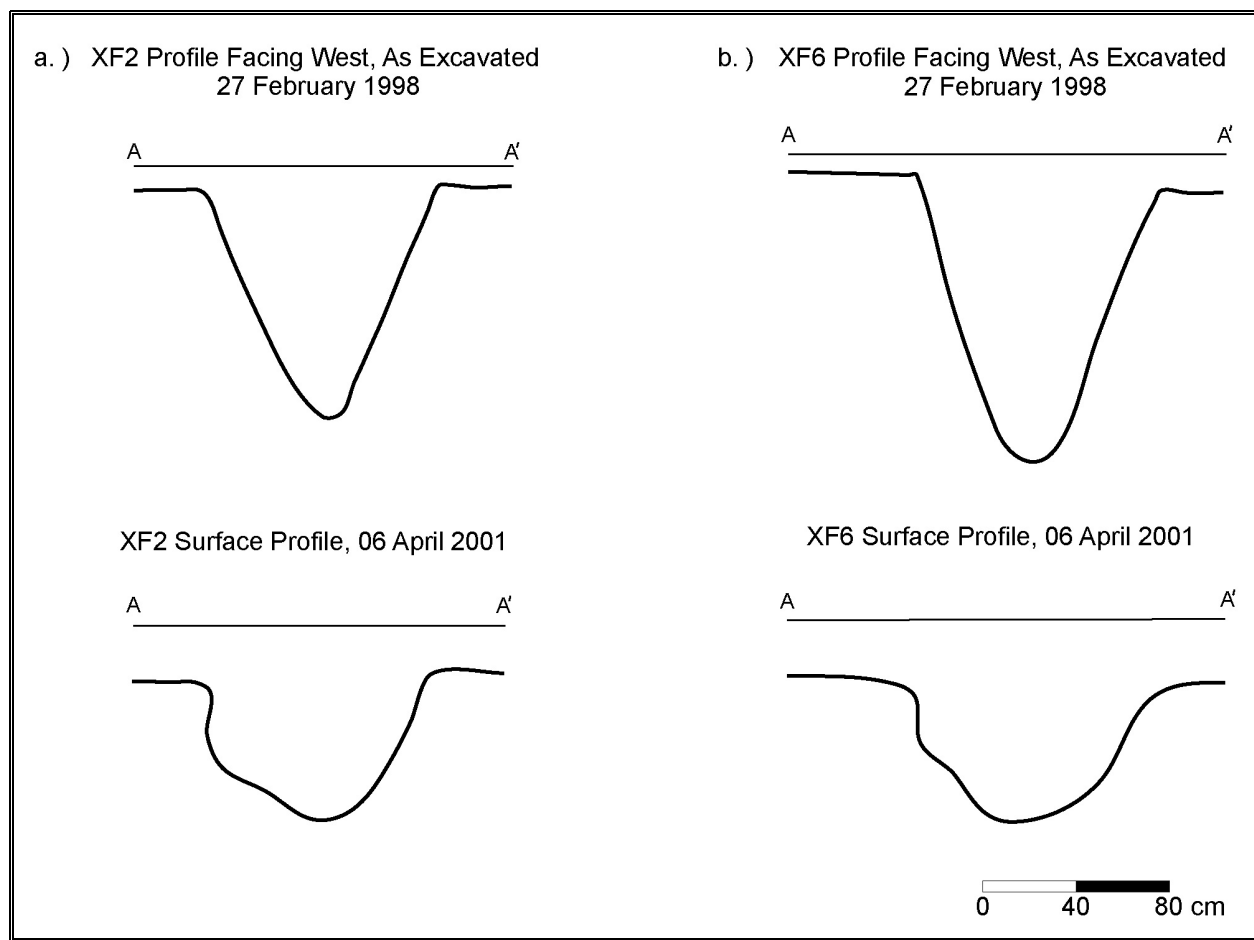


Figure 10.45 Morphological Comparisons for Deep Conical Basins (XF 2 and XF 6) over the Course of the Observation Period

XF 3

XF 3 was a shallow circular, bowl-shaped basin. The original experimental excavation was 0.90 m in diameter by 0.42 m deep. Backdirt was removed from the vicinity of XF 3. Within a week of construction, earthworm activity was apparent throughout the feature. As the season progressed, the rainfall smoothed the edges and walls and an accumulation of soil and debris was noted at the bottom of the feature. However, erosion of the feature walls appeared less pronounced than on deeper sided excavations. Some frost disturbance of the feature walls was noted. By late March 1998, weeds were growing around the rim of XF 3. The location of Feature XF 3 received significant solar exposure, and a notable increase in vegetative growth over the shaded experimental features was noted. Approximately 10 cm of infilling was recorded during the three-year observation period with an original depth of 0.42 m and an ending depth of 0.32 m (Figure 10.46).

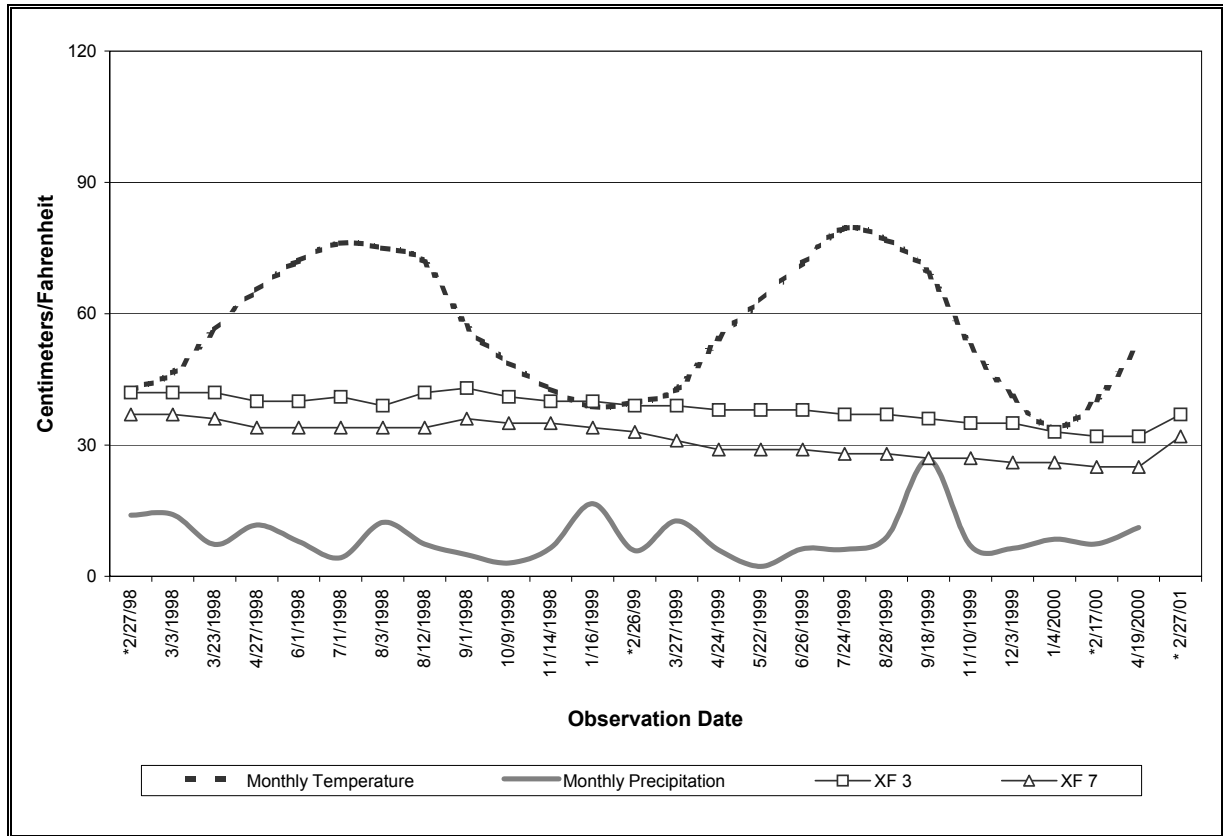


Figure 10.46 Rate of Infilling Compared to Monthly Precipitation and Temperature for XF 3 and XF 7

Comparison of the initial and three-year profiles indicated a degree of slumping for XF 3 (Figure 10.47a). This slumping was most notable at the top of the feature as the surface around the initial opening had caved in and left the sharp cuts less evident. The bottom of the feature became more rounded and lacked the levelness of its initial form. The south half of the feature experienced more weathering and lost a greater degree of its initial morphology. Again, this may be due in part to less exposure to the sun, resulting in moss growth that stabilized the rim of the feature allowing a greater degree of wall slump below the moss.

XF 4

XF 4 was a deep circular feature that was excavated and immediately backfilled. The original excavation measured 1.00 m wide by 1.00 m deep. This feature type was intended for re-excavation and evaluation for microstratigraphic characteristics.

Soils in XF 4 began to subside noticeably within a week of being filled. However, other than a gradual deflation of the fill, no visible changes were observed. Vegetation did not take hold of the surface of XF 4 until the first week in May 1998. This was more than a month later than on the experimental features left open. By the end of summer 1998, XF 4 was completely covered in vegetation. At the end of the study, XF 4 had subsided 11 cm below the ground surface (Figure 10.48). Subsidence was greatest on the edges of the feature as the center subsided only eight centimeters (Figure 10.49a). Re-excavation of the feature has not yet been undertaken.

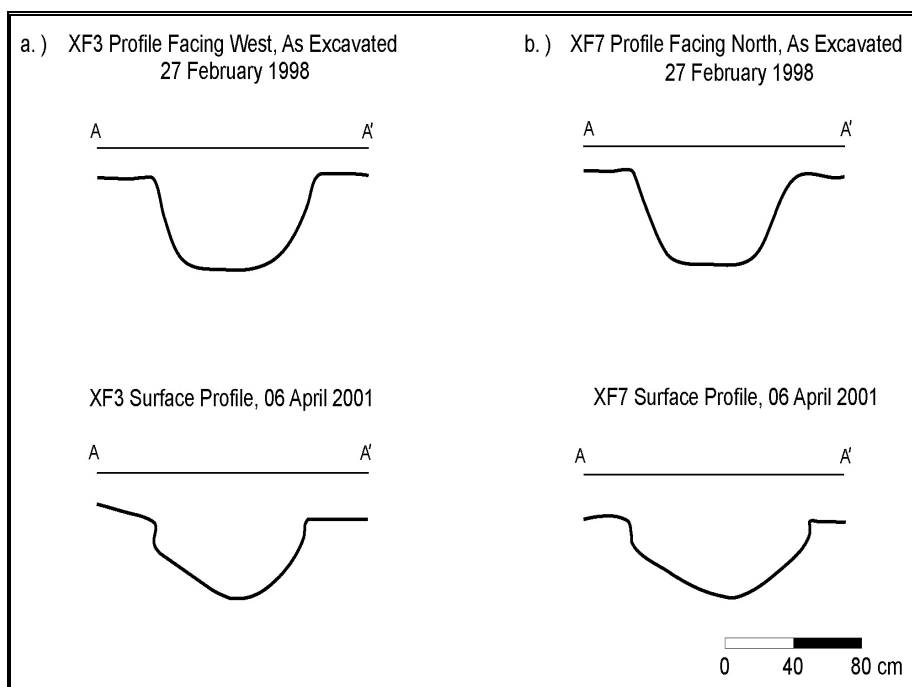


Figure 10.47 Morphological Comparisons for Shallow Bowl-shaped Basins over the Course of the Observation Period

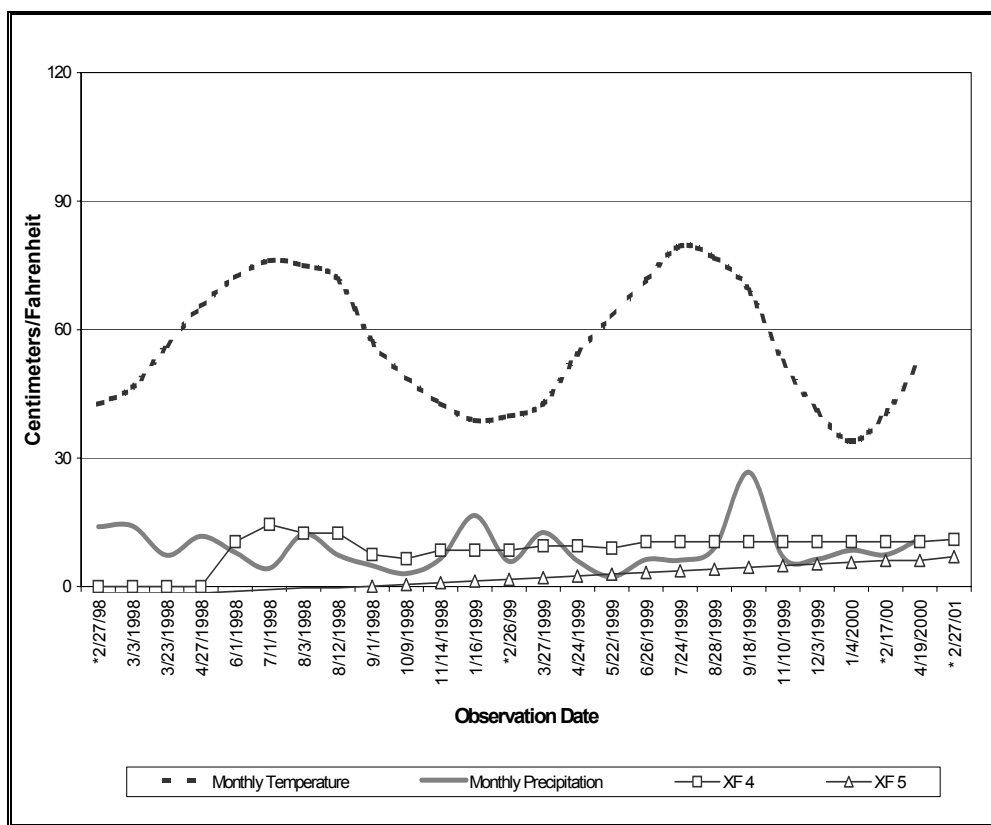


Figure 10.48 Rate of Subsidence Compared to Monthly Precipitation and Temperature for XF 4 and XF 5

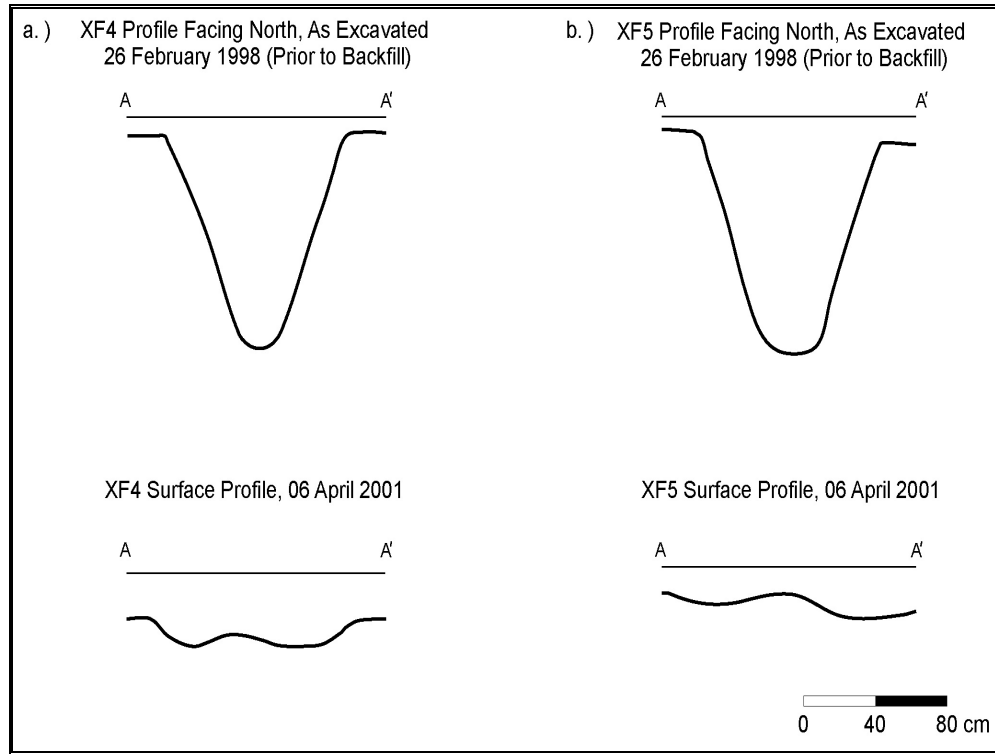


Figure 10.49 "As Excavated" and Surface Profiles of Backfilled Basins

XF 5

XF 5 was a deep circular feature measuring 1.00 m wide by 1.00 m deep. It was excavated through the overlying strata into the subsoil, and then immediately backfilled. Subsidence in XF 5 was noticeable within a week of the excavation and refilling. No other visible disturbances on the surface were observed throughout the study other than a gradual deflation of the fill. Plant growth on the surface of XF 5 was recorded for the first week in May 1998.

By the end of summer 1998, XF 5 was completely covered in vegetation. Observations in the Fall of 1999 noted a ~2.00 m sapling growing near the eastern edge of the feature. This feature type was intended for re-excavation and evaluation for microstratigraphic relationships. At the end of the study, XF 5 had subsided seven centimeters from its original depth (Figure 10.48). A surface profile obtained at the end of the three year observation period revealed a slightly undulated surface with the lesser subsidence occurring within the center of the feature (Figure 10.49b). Re-excavation of XF 5 has not yet been conducted.

XF 6

XF 6 was a shallow circular bowl-shaped basin. The original excavation measured 1.00 m in diameter with a maximum depth of 1.17 m. The excavated backdirt was left in the vicinity of the XF 6 orifice. Excavations cut into sand and gravel deposits of the Columbia Fm. The coarser nature of the soils encountered in XF 6 seemed to have resulted in greater erosion of the side walls than in XF 2, which had a nearly identical morphology.

Marked changes began to occur within a week of construction. Rains began smoothing and rounding the sides and edges of the feature, depositing minor amounts of soil at the base of the feature. Earthworms began tunneling throughout A- and E-horizons and within two weeks, were well established in the bottom of the feature. The first small wall collapse occurred within two weeks of construction.

Freezing weather in mid-March 1998 caused areas of ice to form in the upper half of XF 6, where water had perked out of the sides of the feature. This freezing loosened soils, which washed into the feature bottom during ensuing rains. Periodic rains during March inundated the basin and resulted in the influx of soil and debris into the feature. Side wall erosion was noted along the full vertical extent of the feature. Some size sorting of soil particles was noted as a result of side wall erosion, with gravels left in the side walls as the surrounding sandy matrix gradually eroded into XF 6. Shallow gullies also began to form at the edge of XF 6. The frequent rains kept the feature walls soft and moist, facilitating ongoing worm action and minor soil sloughing. Vegetation began to grow around the rim of XF 6 by the first week of April and, within another two weeks, extended out of the upper side walls. By early May, weeds were present at the bottom of XF 6 and vines from adjoining areas had entered the feature.

During April and May, bioturbation and minor sloughing continued to undercut the lower edges of the side walls, causing further erosion and numerous small wall collapses. Initial depth recordings showed 18 cm of infilling in the first two months. Faunal activity in XF 6 included the presence of a toad recorded in late April 1998. It was not noted at a later date and it is unknown whether it escaped or was eaten by a predator.

The depth recordings of XF 6 showed a change from 1.17 m to 0.64 m over the course of the three-year observation period (Figure 10.44). Comparison of the initial and three-year profile showed significant changes to the morphology of XF 6, as expected from the degree of infilling expressed in the depth changes. The steeply sloping sides of the feature were highly weathered, had become more gradually tapered, and lacked the sharp cuts initially present (Figure 10.45b). The deep conical shape had been transformed to a less regular and shallower form that bore little resemblance to the initial excavated shape. The surface adjacent to the feature opening also experienced slumping as indicated by its uneven appearance and rounded edges. No moss was observed growing on or around this feature.

XF 7

XF 7 was a shallow circular bowl-shaped basin measuring 0.90 m wide by 0.37 m deep. Backdirt was left in the area around XF 7. Within a week of construction, earthworm activity was apparent throughout XF 7, leaving soil mounds and fecal matter that washed into the feature bottom at the first rain. As the season progressed, the rainfall smoothed the edges and walls of XF 7 and an accumulation of debris was noted. Frost action also resulted in the displacement of soil, but apparently to a lesser degree than in the deeper, steep-sided features. Wall slumping and soil sloughing caused by rain events also appeared to be less pronounced.

Feature XF 7 was located in a shaded area. This appeared to initially retard vegetative growth. Later in the growing season, however, XF 7 became fully obscured. Depth recording taken over the course of the three-year observation period showed a change of only five centimeters (Figure 10.46).

The morphology of XF 7 experienced some change over the study period that is evident in a comparison of the initial and third year profiles (Figure 10.47b). The steep sides and flat bottom weathered and become more gradually tapered to a rounded bottom. The surface edges also become more rounded and showed a small degree of slumping. No moss was observed growing in or around XF 7.

XF 8

XF 8 was a large bi-level feature with a narrow, D-shaped basin or “sub-basement” set into a wide, shallow “living floor” area. The living floor area was 3.16 m at its greatest dimension and was excavated to a depth of 0.16 m, while the “sub-basement” was 0.73 m below ground surface. The “living floor” area was thoroughly trampled after excavation in an attempt to simulate a limited daily usage. XF 8 was located at the eastern end of the experimental plot and was well shaded for most of the day. The backdirt was left dispersed in the area adjacent to the excavation.

Worm activity in XF 8 was noted in the sub-basement and on a slight shelf halfway up the eastern wall very shortly after construction of the feature. Drainage of the underlying soils was moderate at best, any substantial rain tended to leave standing water in the deepest portion of the excavation, drowning a large number of earthworms. Repeated rains resulted in the erosion of the feature walls and washed quantities of the backdirt into the excavations. Following the subsidence of the standing water, earthworm activity resumed, and fecal matter and minor soil displacement associated with the tunneling once more became apparent. In mid-March, a series of freezes slowed the earthworm activity and the XF 8 sub-basement was lined with ice spikes, resulting in minor frost heaving. Late March brought additional spring rains, resulting in additional input of soil into XF 8, especially the deeper section. Erosion of the side walls and around the rim was noted. The onset of vegetation growth appeared to anchor some of the looser soil. The vegetation tended to grow more readily on the southern facing portion of the feature, apparently due to increased solar exposure in that area.

By early April 1998, minor soil slumps occurred in the lower portions of XF 8, especially in the sub-basement area. These slumps appeared to be caused in part by soil desiccation brought on by a period of dry weather. The periods of soil drying were short-lived and April brought more rains, resulting in additional erosion of the feature sides. Small pebbles dropped out of the walls and side walls became very uneven and craggy. Earthworms were not the only fauna observed in XF 8. Flies were also observed on the bodies of decaying earthworms in the bottom of XF 8 and were likely laying eggs there.

Maple seed pods were observed in XF 8 in May 1998; by June, five silver maple saplings had rooted. One sapling was located on the living floor near the southwest edge of the sub-basement. The other four saplings were evenly spaced in the sub-basement floor. In July, a sixth maple sapling was recorded on the extreme northern edge of the living floor surface; one of the saplings in the sub-basement had grown about 0.60 m. Throughout July, additional maple saplings were observed growing on the living floor. By September 1998, the saplings in the sub-basement were approximately 0.90 m high. At the end of the observations, the saplings within the sub-basement were over 1.50 m in height and were 1.5 cm in diameter.

Measurements of depth were taken at two different locations for XF 8: in the center of the sub-basement and on the shallow living floor. A change of depth of 0.73 m to 0.52 m was recorded in the deep “sub-basement” area. Measurements of the “living floor” surface of XF 8 recorded an erosion of the original surface from 0.16 m to 0.23 m over the course of the three-year observation period (Figure 10.50).

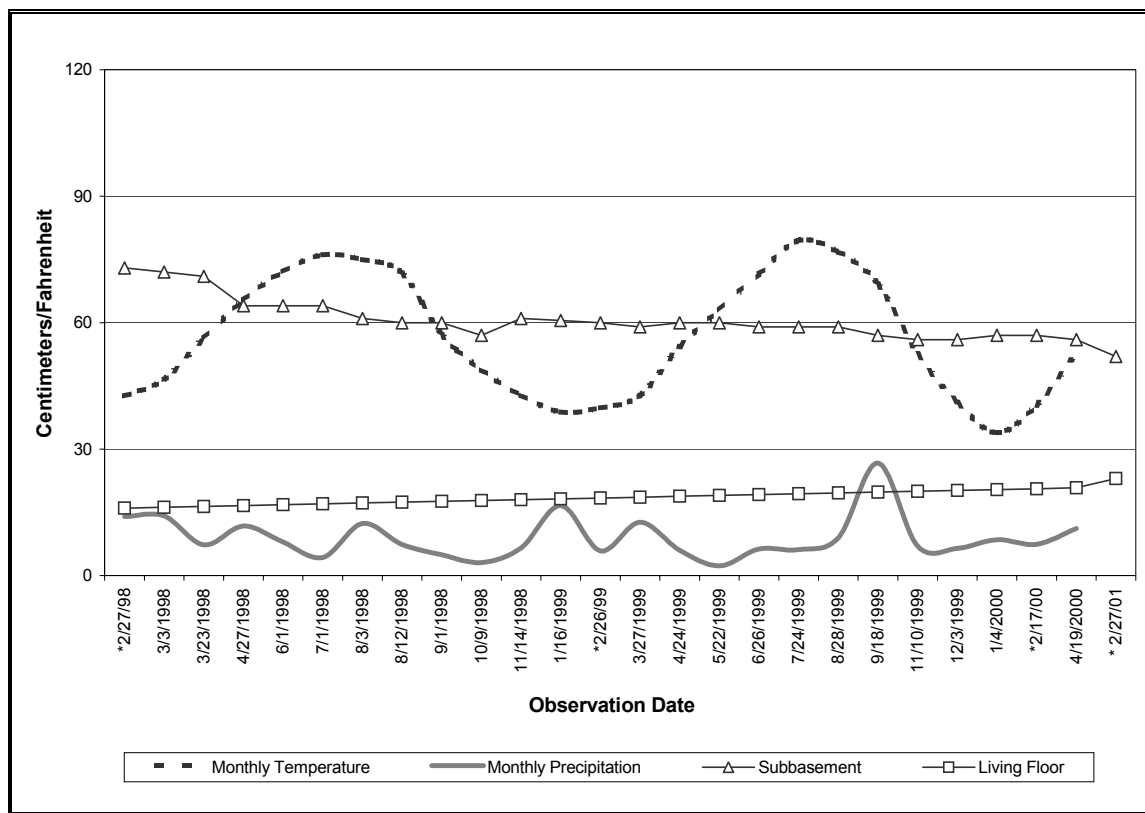


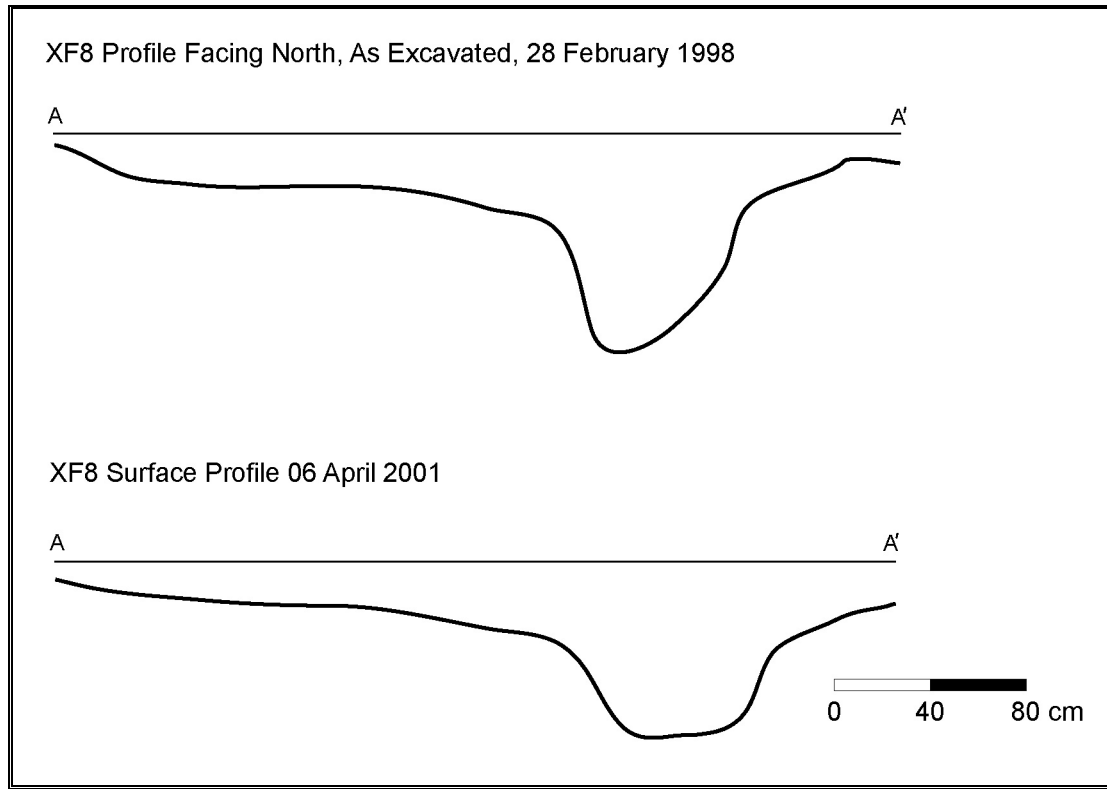
Figure 10.50 Rate of Infilling Compared to Monthly Precipitation and Temperature for XF 8

Examination of the opening and three-year profiles of XF 8 revealed changes in the morphology of the feature (Figure 10.51). The sharp edges of the feature had been filled in first, resulting in a more gradual tapering of the side walls and a more level and rounded bottom. Slumping was apparent in the upper, shallower portion of XF 8 and was now smoother, with the original cuts masked by infilling.

Comparisons and Summary

A variety of natural environmental processes were viewed throughout the study time frame and showed a tempo and mode to various processes (e.g., weather changes, animal interactions, and plant growth). For open experimental features, a collapse of side-walls and a change in general morphology was observed. The backfilled experimental features were subject to animal burrowing and plant growth in their upper horizons, causing movement of sediments. The observational information indicated that open and closed experimental features immediately interact with the natural environment in numerous ways, and that basin infills are the cumulative effect of pre-burial and post-burial processes. Variations in feature depth were recorded through

the duration of the study and were compared with local temperature and precipitation information.



**Figure 10.51 Morphological Comparisons for XF 8
over the Course of the Observation Period**

Geomorphology

Geomorphological observations were constant in all experimental features and natural occurrences resulted in the accumulation of sediments in the feature bottoms and reshaping of the interior walls. Washing in of sediments, slumping of feature walls, smoothing resulting from rain, cracking from dry conditions or ice intrusions, and crusting indicative of differential surface drying were all observed in the experimental features (Table 10.2) (Figure 10.52 and Figure 10.53).

Hydrology

Hydrological occurrences were also constant with the presence of standing water, frost and ice, and snow observed in all experimental features. Shallow gullies or rivulets indicative of water drainage were noted for the shallow living floor portions of both XF 1 and XF 8 (Table 10.2 and Figure 10.54 and Figure 10.55).

Table 10.2 Qualitative Observations on Experimental Features

OBSERVATION	XF 1 living floor	XF 1 sub-basement	XF 2	XF 3	XF 4	XF 5	XF 6	XF 7	XF 8 living floor	XF 8 sub-basement
<i>Geomorphology</i>										
Washed in sediments		X	X	X			X	X		X
Slumping		X	X	X		X	X	X		X
Smoothing (wet conditions)		X	X	X	X	X	X	X		X
Cracking (dry conditions)		X	X	X	X	X	X	X		X
Crusting (dry conditions)		X	X	X			X	X		X
Subsidence					X	X				
<i>Hydrology</i>										
Standing water	X	X		X						X
Frost/Ice	X	X	X		X	X	X	X		X
Snow	X	X	X	X		X	X	X		X
Shallow gullies	X								X	
<i>Floral Intrusion</i>										
New Growth										
Moss		X	X	X					X	X
Mushrooms			X					X	X	
Plants	X	X	X	X	X	X	X	X	X	
Trees						X			X	X
Floral Debris										
Leaves	X	X	X	X			X	X		X
Sticks/ Branches	X	X	X	X				X		X
Flower Blossoms	X	X	X	X			X	X	X	
Fruit		X								
Seeds								X	X	
<i>Faunal Intrusion</i>										
Active Presence										
Centipedes/ Millipedes		X	X	X			X			X
Spiders		X					X			
Caterpillars		X					X			
Flies		X								X
Beetle		X	X							

Table 10.2 Qualitative Observations on Experimental Features (Continued)

OBSERVATION	XF 1 living floor	XF 1 sub-basement	XF 2	XF 3	XF 4	XF 5	XF 6	XF 7	XF 8 living floor	XF 8 sub-basement
Crickets		X	X				X			
Cicada				X						
Slugs		X	X				X			
Snails							X			
Frogs		X	X							
Toads		X	X				X			
Rat Snake		X								
Small mammal tracks			X		X					
Deer Tracks	X				X				X	
Active Burrowing										
Worms	X	X	X	X			X	X	X	X
Ants		X	X	X			X			X
Bees		X		X						
Beetles		X								
Frogs		X	X							
Toads		X	X							
Mammal Digging	X									
Mortality										
Worms		X								X
Bees		X								
Crickets		X								
Frogs		X								
Rat Snake		X								
Bird										X
Shrew		X								
Faunal Debris										
Feathers		X	X							
Bird Droppings		X								
Deer Hair									X	
Locust Shell		X								

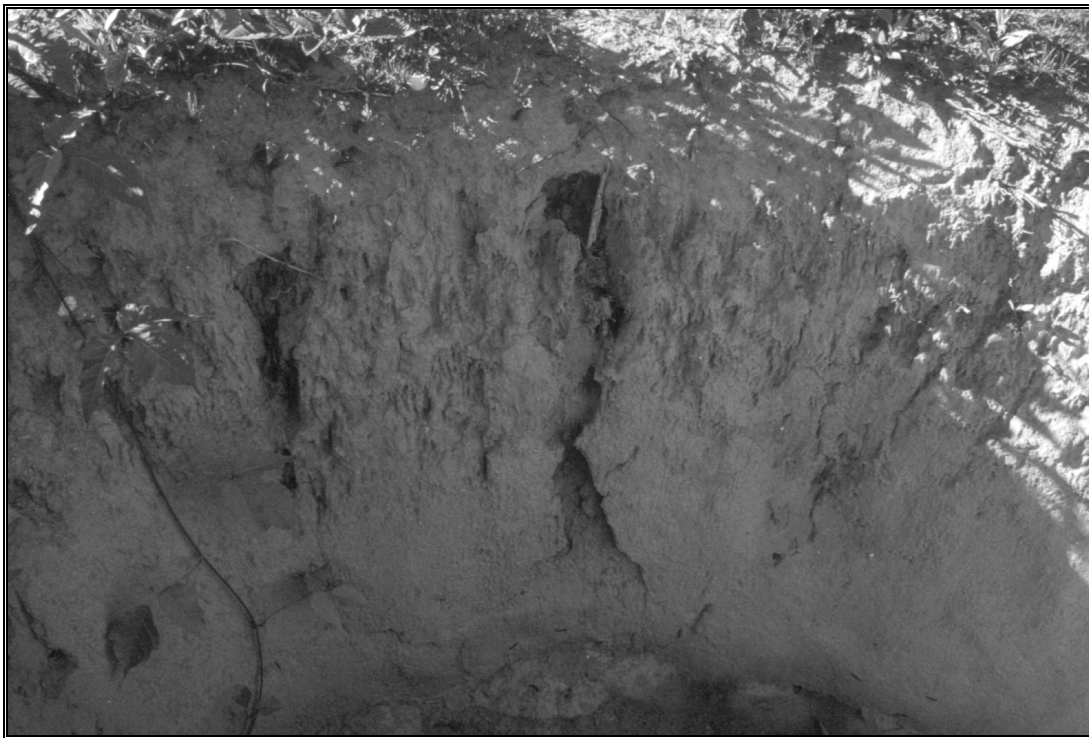


Figure 10.52 Geomorphological Observations-Drying and Cracking



Figure 10.53 Geomorphological Observations - Smoothing from Rainfall



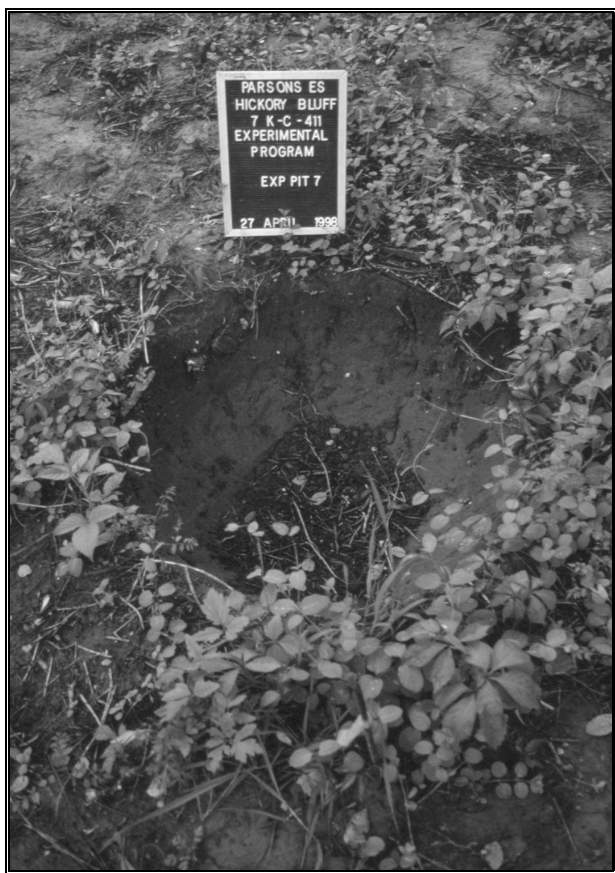
Figure 10.54 Hydrological Observations - Standing Water in XF 1



Figure 10.55 Hydrological and Floralturbation Observations - Standing Water and Floral Debris in XF 8

Floralturbation

Observations associated with floral intrusions consisted of two basic types: intrusion of floral debris from plants in the vicinity and actual growth of plant life within the features themselves. Vegetation from around the experimental features was recorded as encroaching and enveloping the feature openings. Floral debris, such as leaves, sticks, flower petals, and fruit, were deposited within the experimental features (Figure 10.56) and transport was usually the result of storm events with rain and/or wind, and season (Fall and Winter). Plant growth within the experimental features was dominated by grasses, forbs, and vines; tree saplings were observed in XF 1, XF 5, and XF 8 (Figure 10.57). Moss and mushrooms were noted in five features (XF 1, XF 2, XF 3, XF 7, and XF 8) including both exposed and shaded locations.



**Figure 10.56 Floralturbation Observations
- Plant Growth in and Around XF 7 in
April 1998**



**Figure 10.57 Floralturbation Observations
- Plant Growth in and Around XF 7 in
August 1998**

Faunalturbation

Faunal intrusions consisted of four basic categories: active or live presence, active burrowing, mortality, and presence of debris. Insects, invertebrates (slugs and snails), amphibians, reptiles, and mammals were all observed in various features (Table 10.2). Ground and wall disturbing activities included active burrowing, scratching and digging by insects, invertebrates, and amphibians; worm disturbance was the most prevalent. Faunal residue within the features was sparse and consisted of feathers, droppings, hair, and a locust/cicada shell.

Evidence of animal mortality was observed in the sub-basement portions of XF 1 and XF 8. Worm drownings were the most common type of mortality noted and were associated with episodes of heavy rains creating standing water in the features. Cause of death for larger fauna, such as amphibians, reptiles, birds, and mammals, was undetermined. However, the depths of the sub-basements in XF 1 and XF 8 (over 1 m), may have contributed to entrapment. These portions of these features may have been too deep for easy escape of smaller fauna. A dead shrew was noted in the sub-basement of XF 1; scratch marks on the west and north walls were also observed and may indicate attempts at escape. The corpses of the dead frog and rat snake in XF 1 remained in the feature bottom and their deterioration was recorded for 2 weeks (Figure 10.58); however, the remains of the shrew (XF 1) and the bird (XF 8) disappeared within a few days of documentation. An active fox borrow was observed on the southern edge of the experimental plot.



Figure 10.58 Faunal Turbation Observations - Remains of Frog and Rat Snake in XF 1

Depth Comparisons

The four shallow surfaces, the living floors of both XF 1 and XF 8, and the two backfilled features, XF 4 and XF 5, exhibited the smallest change in depth (less than 12 cm difference) (Table 10.3). None of the surfaces represented accumulation and infilling of sediments; the surfaces indicated no change (XF 1), erosional activity with no additional accumulation of sediments (XF 8), or subsidence (XF 4 and XF 5). The two shallow features, XF

3 and XF 7, exhibited only 5-10 cm of sediment accumulation and infilling. The four deeper surfaces, the sub-basements of both XF 1 and XF 8, and the two deep conical features, XF 2 and XF 6, exhibited the greatest change in depth from 0.21 m in XF 8 to 0.48 m in XF 1 (east end). The increase in sediment infilling and accumulation in these features was probably a direct result of the depth of the original feature creating larger areas of exposed soil susceptible to slumping.

Table 10.3 Experimental Feature Depth Comparisons

Feature Number	Original Depth (m)	Final Depth (m)	Change in Depth (m)	Type of Change	Percentage of Change
XF 1 center of sub-basement	1.00	0.70	0.30	Infilling	30.0
XF 1 east end of sub-basement	1.03	0.55	0.68	Infilling	66.0
XF 1 living floor	0.10	0.10	0.00	None	0.00
XF 2	0.97	0.59	0.38	Infilling	39.1
XF 3	0.42	0.37	0.05	Infilling	11.9
XF 4	Ground surf.	0.11	0.11	Subsidence	N/A
XF 5	2 cm above ground surf.	0.07	0.09	Subsidence	N/A
XF 6	1.17	0.64	0.53	Infilling	45.0
XF 7	0.37	0.32	0.05	Infilling	13.5
XF 8 center of sub-basement	0.37	0.52	0.21	Infilling	28.7
XF 8 living floor	0.16	0.23	0.07	Erosion	N/A

Changes in feature depth were recorded on a monthly basis and compared to both temperature and precipitation changes for the study time frame. Using monthly means, the temperature cycle was a relative constant and oscillated with seasonal changes. Monthly changes in precipitation were more discrete; however, with one exception, overall changes in depth were not directly associated with precipitation peaks. In September 1999, Hurricane Floyd impacted the Mid-Atlantic region; monthly precipitation was 10.51 inches. In XF 1, a marked increase in soil accumulation (i.e., decrease in feature depth) was associated (Figure 10.42). In all other experimental features, precipitation peaks did not correlate with decreases in feature depth (Figure 10.44, Figure 10.46, Figure 10.48 and Figure 10.50).

FEATURE CONTOUR MAPPING

Methodology

To more effectively display the variability of form encountered in both basin features and tree mold patterns, a series of three-dimensional surface contour plots was generated using Golden Software's SURFER® program. These plots were based upon measurements collected during feature excavations. The contour plots complemented the more traditional plan and profile views of features, and provided a more detailed depiction of the excavated forms not captured by the two-dimensional drawings.

Early excavations at Hickory Bluff recognized the limitations imposed by depicting basin features with only standard plan and profile views. The bottoms of the basins tended to vary with depth, the overall volume usually decreased, and the surfaces contained a degree of undulation, all of which were not well represented in drawings. An early effort to remedy this situation was to re-draw the feature at the completion of excavating each arbitrary level on the same map. This provided an indication of the changing planview shapes of the features by depth and a reasonable portrayal of their contours (Figure 10.59). These early contour maps, however, tended to be somewhat impressionistic as they were only recorded for the feature edges and not the undulated bottoms or in relation to the surrounding non-feature context.

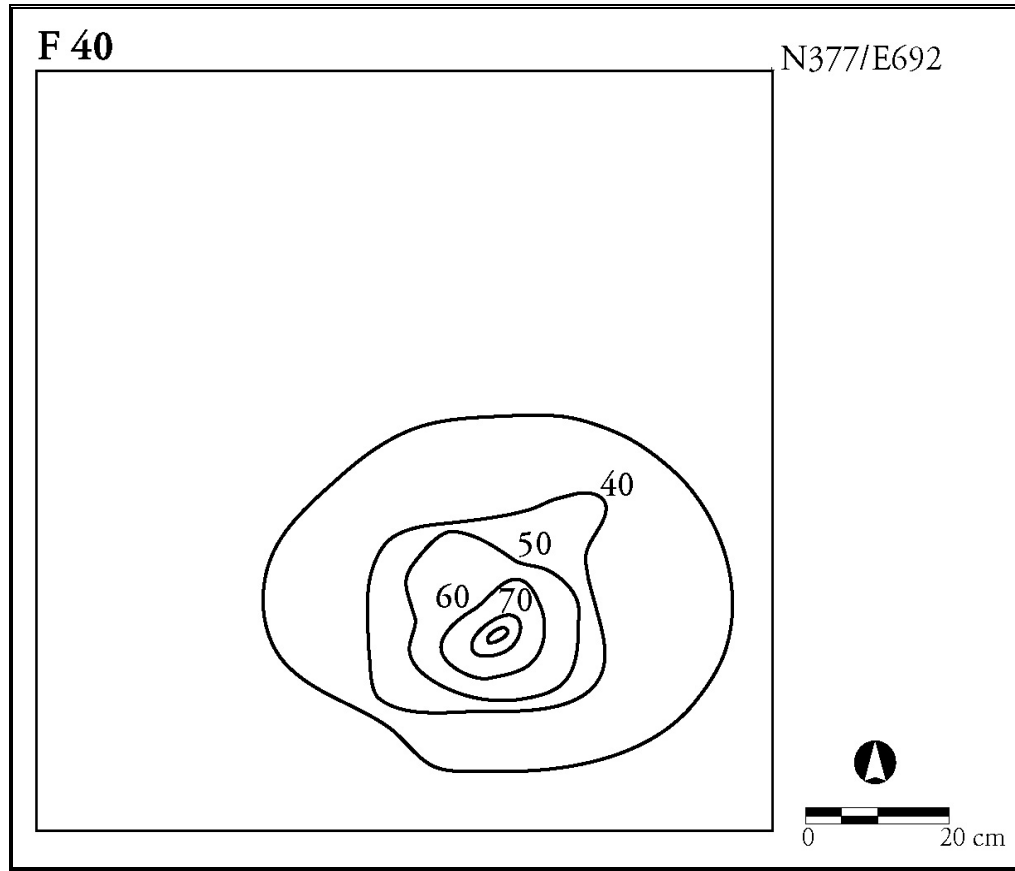


Figure 10.59 Sample Initial Contour Planview for Basin Features

The next stage of contour mapping included a new and important refinement to account for the limitations of the “impressionistic” contour maps: systematic grid point measurements. At the completion of full feature excavation, a series of measurements was recorded across the entire test-unit floor to account for variations along the bottom and the relation of the feature bounds to the surrounding natural stratigraphy. These measurements were initially recorded on a 20 cm grid across the unit floor. After these measurements were taken, contour lines were drawn between points with the same or similar depth measurements (Figure 10.60). These contours, in addition to the planview maps recorded for each level of excavation, illustrated the potential benefits of detailed contour mapping.

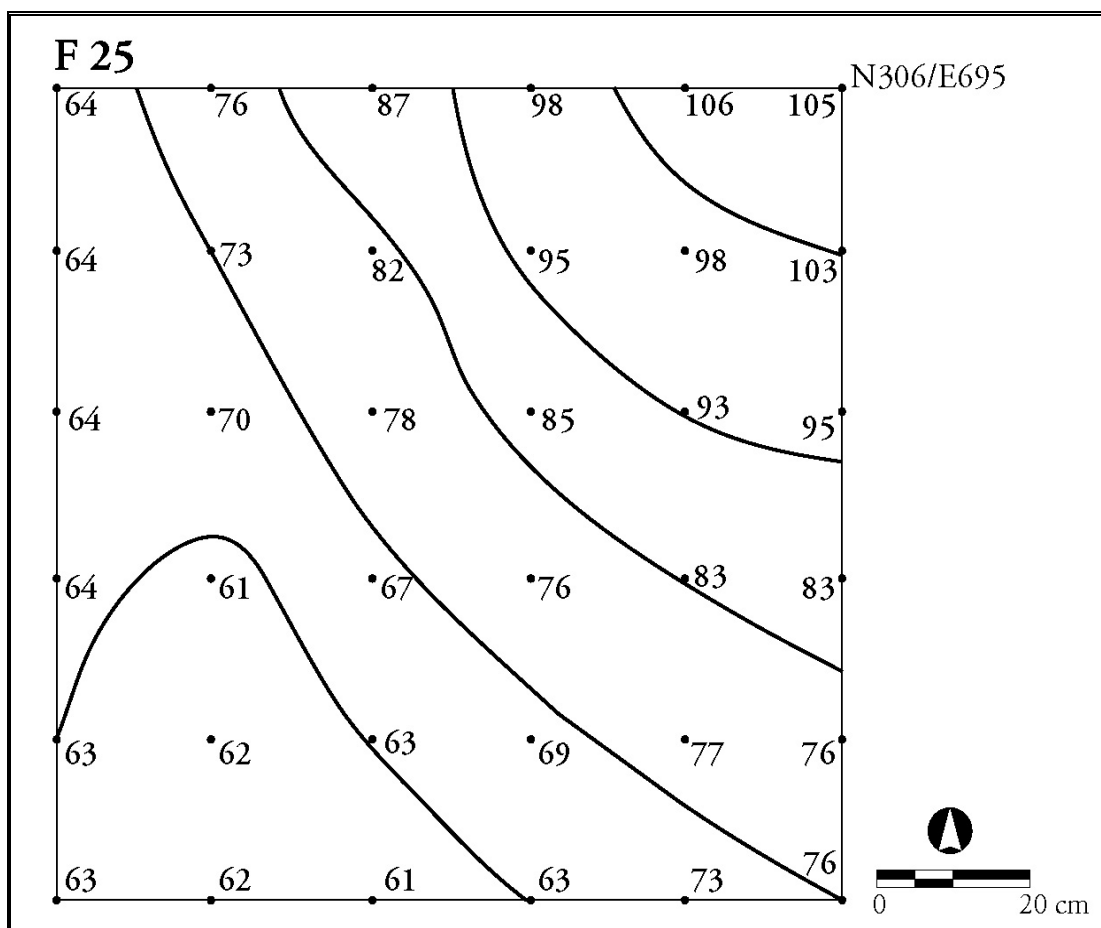


Figure 10.60 Sample Grid Coordinate Contour Planview for Basin Features

The data collected at a 20-cm spacing was used to generate a surface plot; however, the wide interval used for the map seemed to “regularize” the feature to a degree. As a result, the contour interval spacing was reduced to 10 cm and then further, to 5 cm, in an effort to account for the variation, undulation, and irregularity commonly encountered within basin features. The tighter interval allowed for more data points to be collected, so that more of the actual variation was recorded and less space had to be “smoothed” between points by the mapping program.

The raw data were collected in the field using a line-level and tape measure. Depth measurements were taken from the same datum point as the rest of the unit excavation to keep the information consistent. To aid in the collection of data, a 5 cm grid was first etched with a trowel across the floor of the unit, so that the depths could be taken quickly in succession without having to stop and measure placement within the unit. This allowed for the depth measurements to remain consistent with each other and minimized error introduced by repeated starts and stops. The process was aided further with the use of “drawing squares,” which could be used for placement horizontally and vertically, as well as leveled to datum depth to provide a depth reference point (Figure 10.61). Better consistency in data recording was also achieved when the teams maintained their roles for the entire process; that is, one person gathered the measurements while the other recorded. Working in teams provided an internal check to ensure that all points were collected.



Figure 10.61 Employing the Use of "Drawing Squares" at Hickory Bluff

After measurements were taken for the full feature they were input into a large spreadsheet that recorded the x, y, and z coordinates for the full feature and enough of the surrounding plane of origin to provide relief. The surface contour plots were then generated using SURFER®, a computer mapping software package. The program takes the data points entered and connects the contours, projecting a surface. The nature of the program tends to somewhat smooth the lines, but still generates a reasonably accurate depiction of the excavated feature's shape (Figure 10.60).

Although some style of contour data measurements were obtained for most features on the site, not all were chosen to be computer-generated. Features were rejected from computer modeling for different reasons, including: incomplete excavation (i.e., either left in bisection or extending outside of excavation blocks); too much intersection between features, such that the boundaries were blurred; "undercutting," such that a single point had two different depth values; and insufficient surface around the feature to provide adequate contrast. A range of features and experimental tree bisections were included in the contour mapping program, to examine the range of variability of form between and among basin features and tree mold patterns.

Mapping Results

In total, plots of 19 features and tree bisections were generated with three-dimensional contouring. Of these, seven were basin features; five large – Features 1/313, 78 (Figure 10.62), 90 (Figure 10.63), 118 (Figure 10.64), 169 (Figure 10.65); one medium – Feature 137 (Figure 10.66); and one small – Feature 120 (Figure 10.67). Tree mold patterns accounted for seven contours and included varieties found archaeologically, Features 56 and 63 as well as excavated experimentally, BX 1, BX 3, BX 5, BX 7, and BX 10. Three features were included that

represented a combination of natural and cultural modifications – Features 111, 116 (Figure 10.64), and 232 (Figure 10.68). The final two features were selected under different parameters. Feature 100 was a combination of biotic and geomorphic actions and was almost “bell-shaped.” BX 13 was determined after excavation to not be a tree but rather a modern trash pit dug at the site. It was included for comparison with the basins discovered archaeologically.

Overall, the data gathered and processed from the contour plotting was effective in depicting the excavated feature shapes. However, two of the projected contours were not reflective of the actual excavations. The first problematic feature was BX 10, which was completely excavated, but unfortunately located along the slope of the bluff. As a result, the contour depths taken not only recorded the feature, but also the contour of the bluff slope, which was great enough to mask the tree pattern. The combination geomorphic/biotic Feature 100 contour was also distorted, as it had too many undercut portions that could not be reliably generated by the computer to reflect the actual excavated shape (and led to the rejection of several other features before they were input).

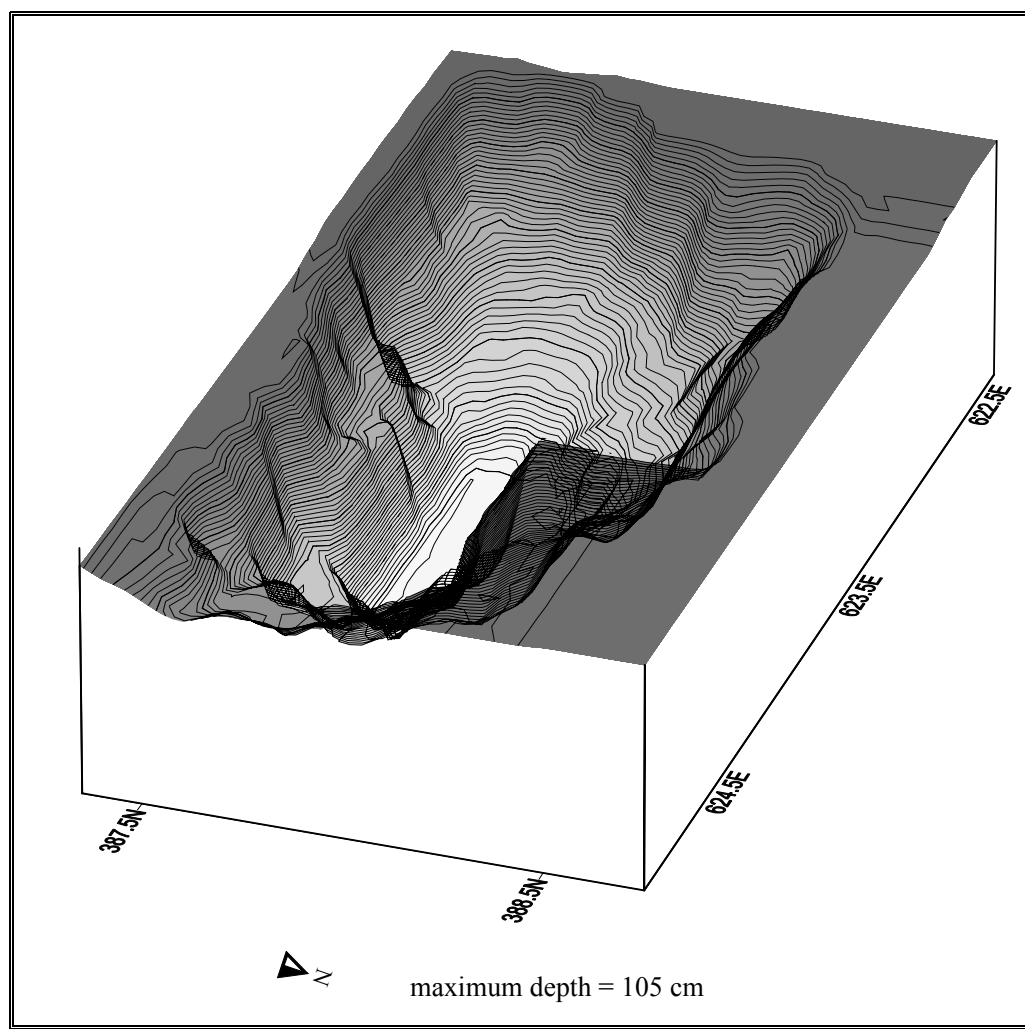


Figure 10.62 SURFER® Generated Topographic Contour Map of Feature 78

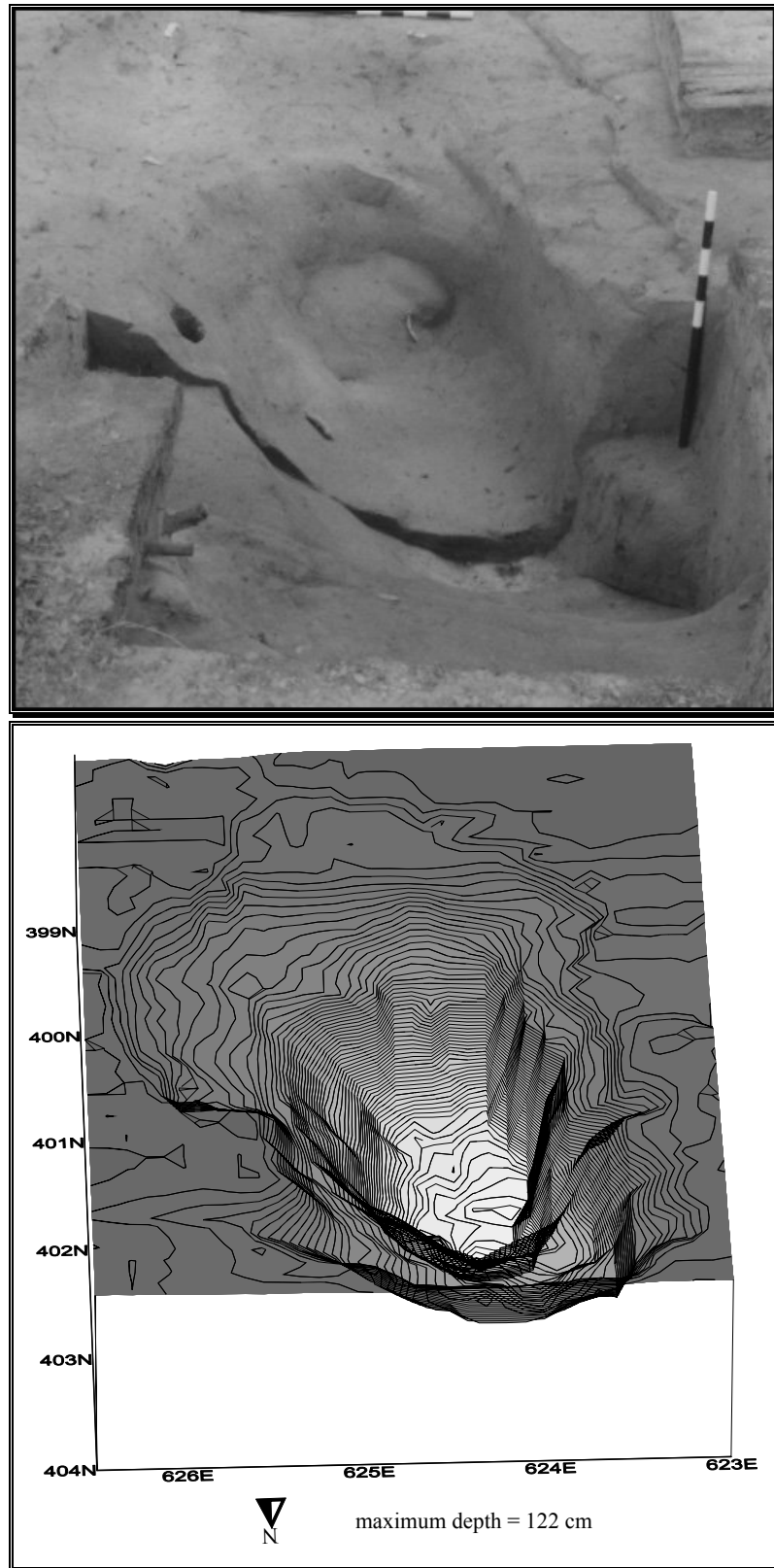


Figure 10.63 Final Excavation Photograph of Feature 90 and SURFER® Generated Topographic Contour Map

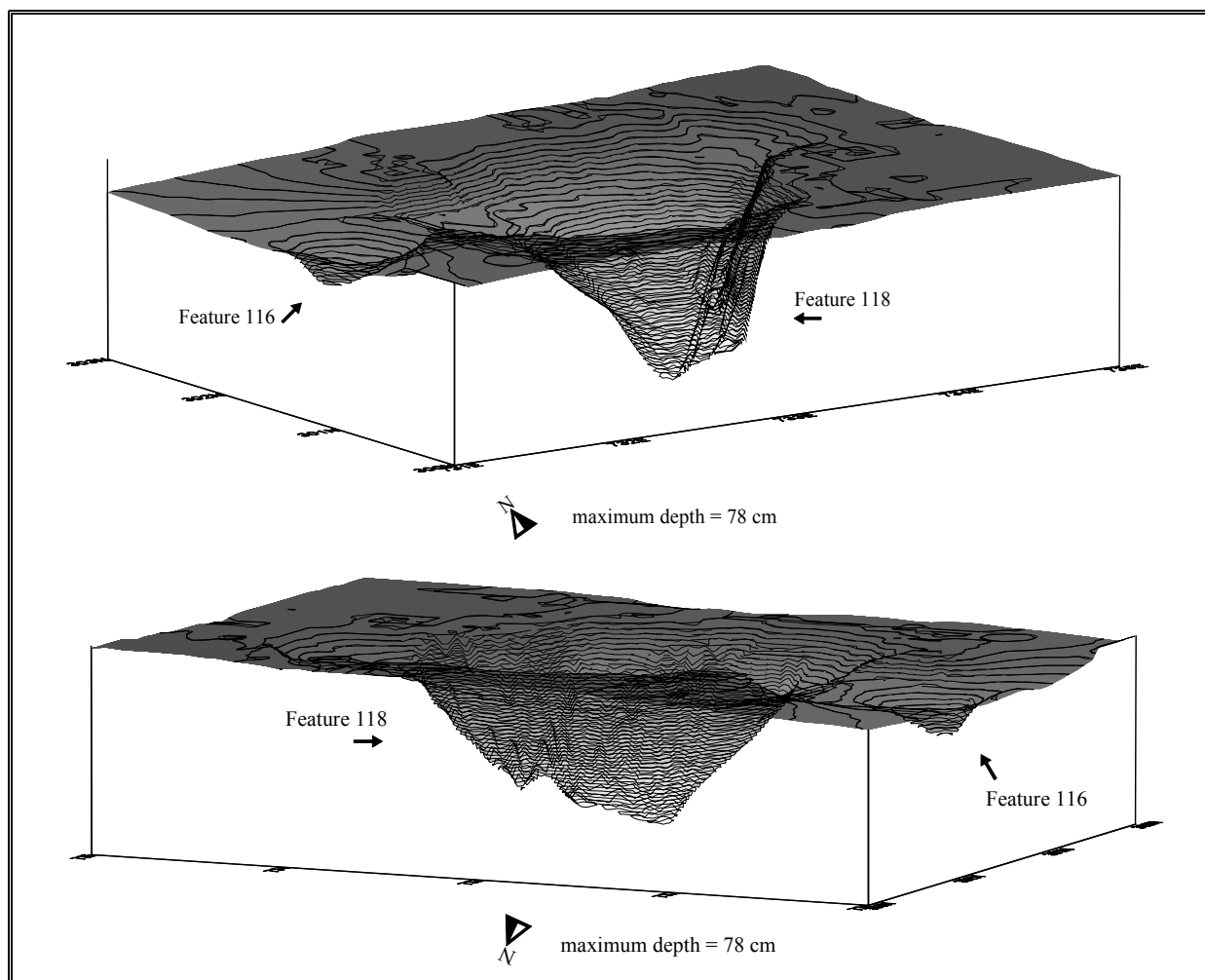


Figure 10.64 SURFER® Generated Topographic Contour Map of Features 116 and 118

Three of the tree bisections were processed in multiple ways as a result of the patterns they possessed. The upper portions of these tree molds penetrated the E-horizon and left a distinct pattern within that horizon. When the E-horizon was removed, the tree pattern was observed continuing into the B-horizon with a somewhat different shape (Figure 10.68). The contours of BX 1 (Figure 10.69), BX 3 (Figure 10.70), and BX 7 (Figure 10.71) were projected with each section separately, as a composite (which tended to obscure the variability of the upper portion), and as a side-by-side comparison. Although these examples were similar (containing distinctive upper and lower portions), they differed from each other in the size and type of root patterns displayed: these features exhibited either vertical tap roots or large roots cutting horizontally across the top of the pattern.

Feature 56 was also projected in several different ways to compare the differences obtained when the contour interval was changed (Figure 10.72 and Figure 10.73). The feature was identified archaeologically, but excavation determined that it was a tree mold pattern. It had a highly undulated base and form. As a result of this and its overall smaller size, contour information was collected on a 2.5-cm grid for greater resolution. Once the data were collected,

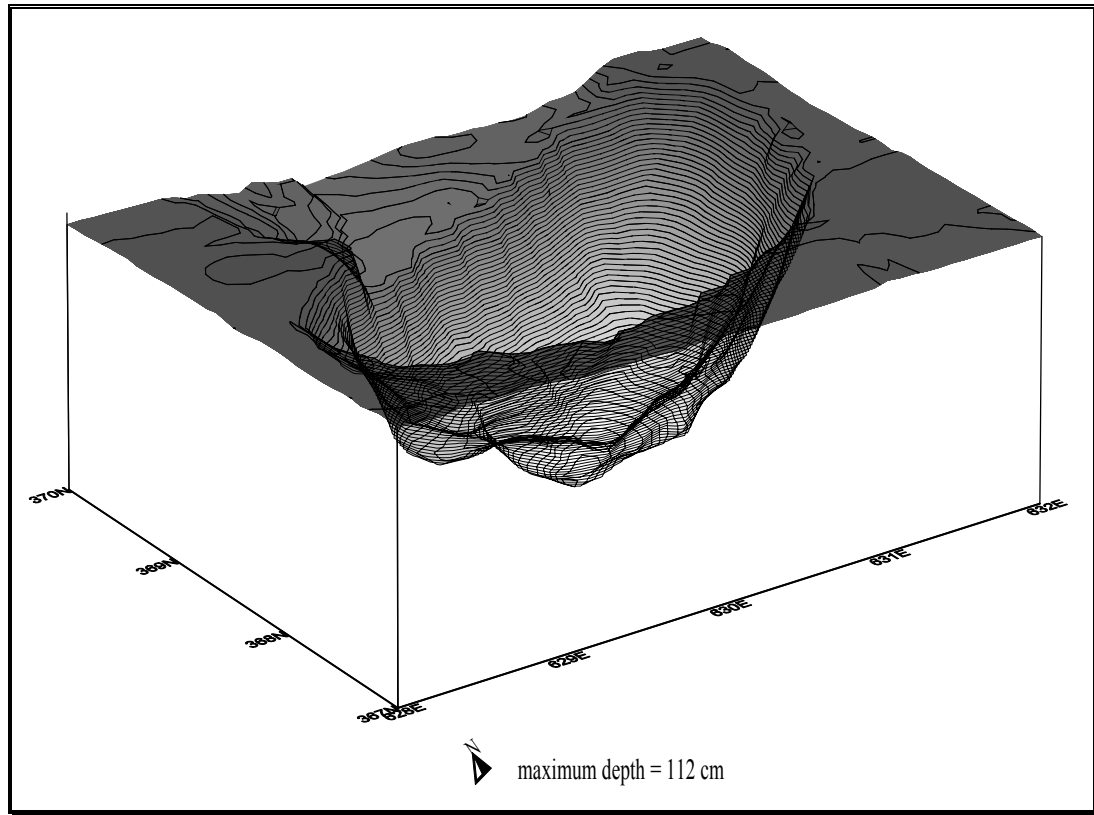


Figure 10.65 SURFER® Generated Topographic Contour Map of Feature 169

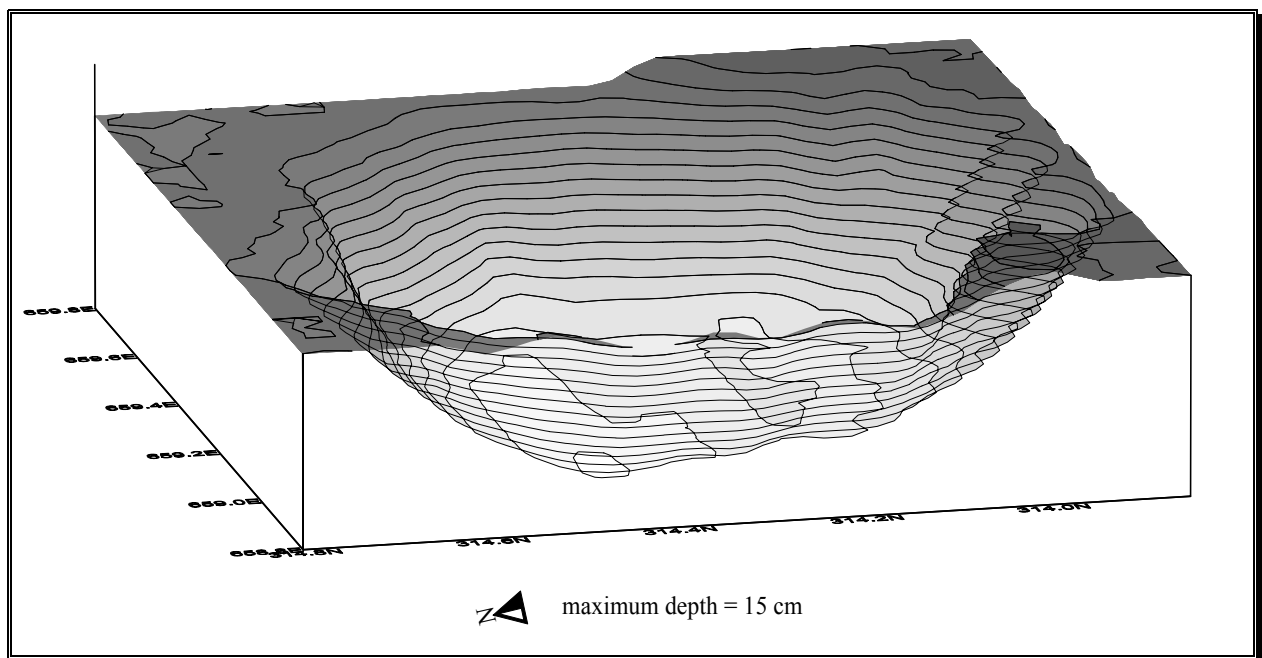


Figure 10.66 SURFER® Generated Topographic Contour Map of Feature 137

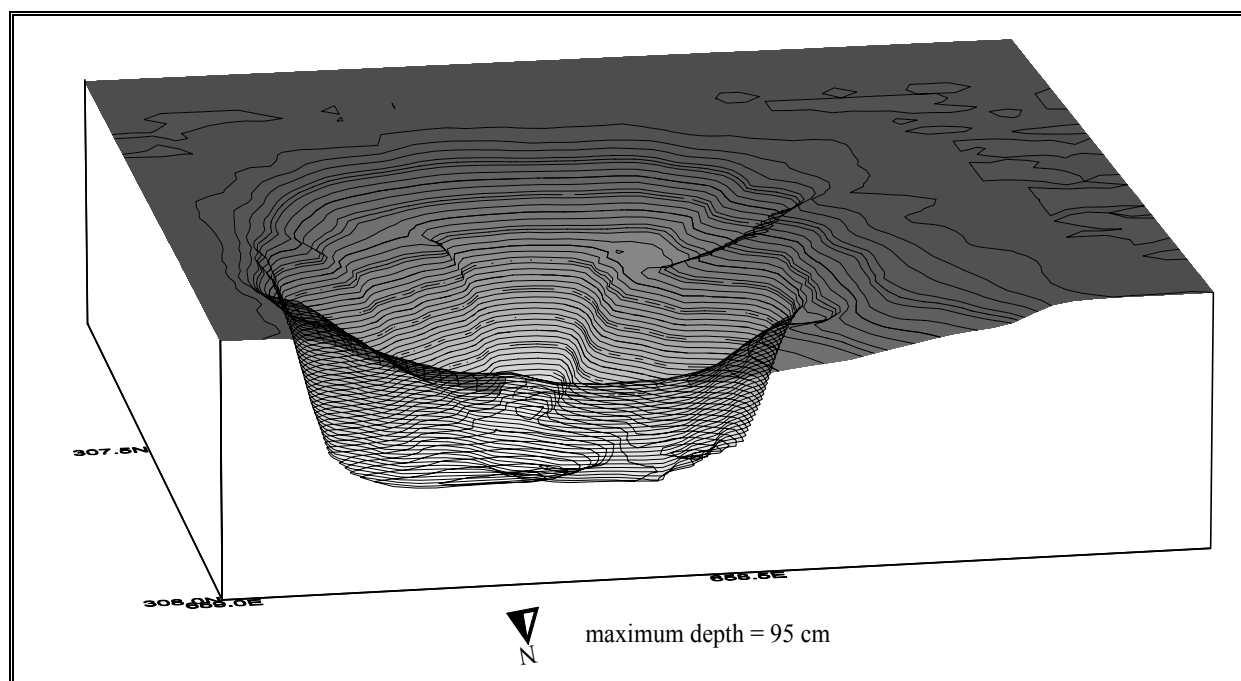


Figure 10.67 SURFER® Generated Topographic Contour Map of Feature 120

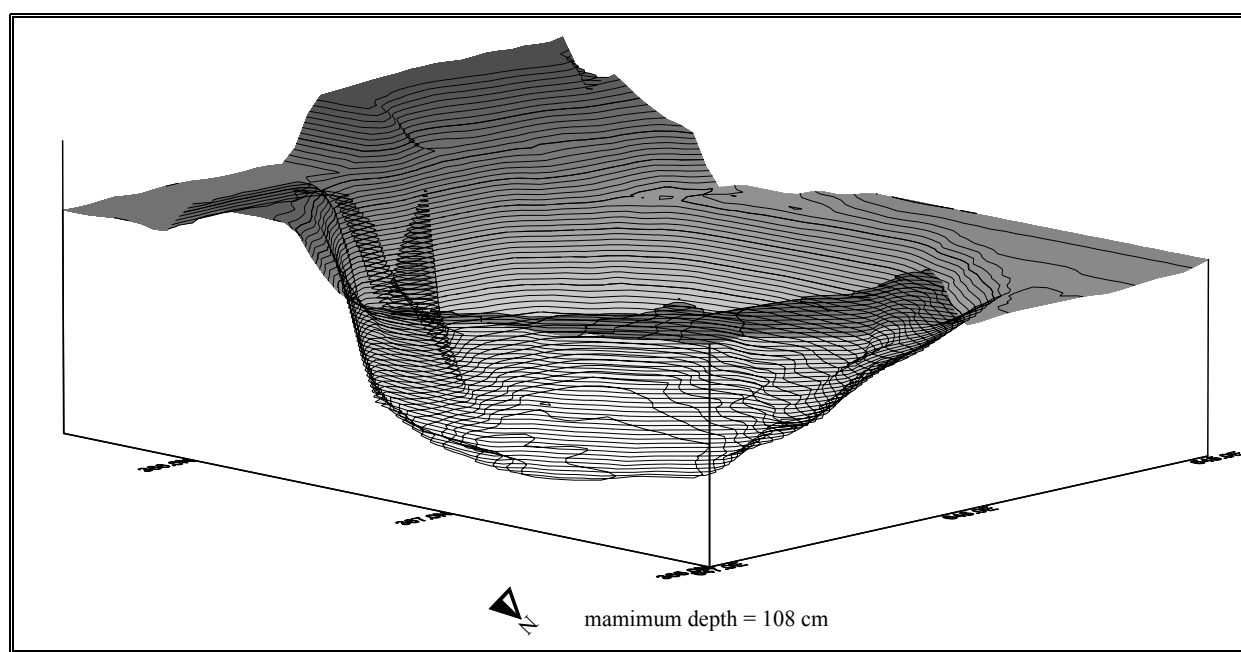


Figure 10.68 SURFER® Generated Topographic Contour Map of Feature 232

for comparative purposes, it was processed at the 2.5-cm, 5-cm, and 10-cm contour intervals. As expected, the level of intricacy decreased with each increase of the contour interval. Although the shape was not entirely regularized by this process, it was visibly smoothed out and revealed much less of the actual variation present in the feature. This was a good experiment for such purposes, as the feature was small and had a range of variation. However, it was decided that for the larger basin features, such a fine level of detail would have been of limited value. The 5-cm contour interval retained enough variability to illustrate the larger features at Hickory Bluff.

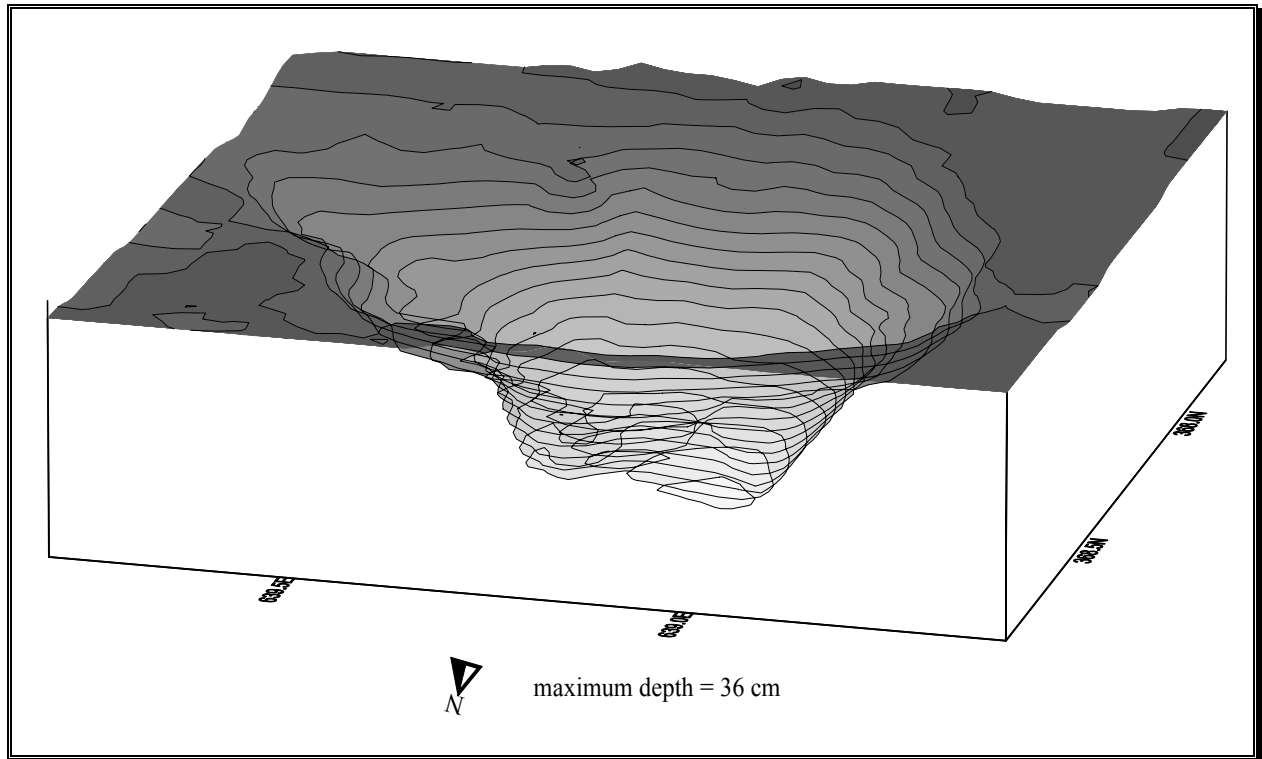


Figure 10.69 SURFER® Generated Topographic Contour Map of BX 1

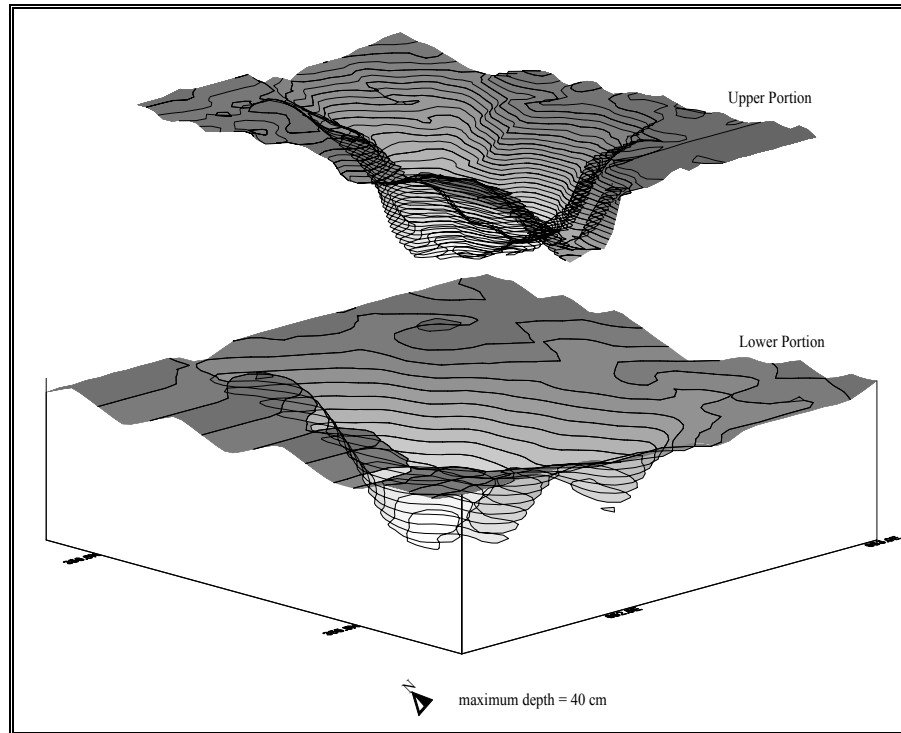


Figure 10.70 SURFER® Generated Topographic Contour Map of BX 3

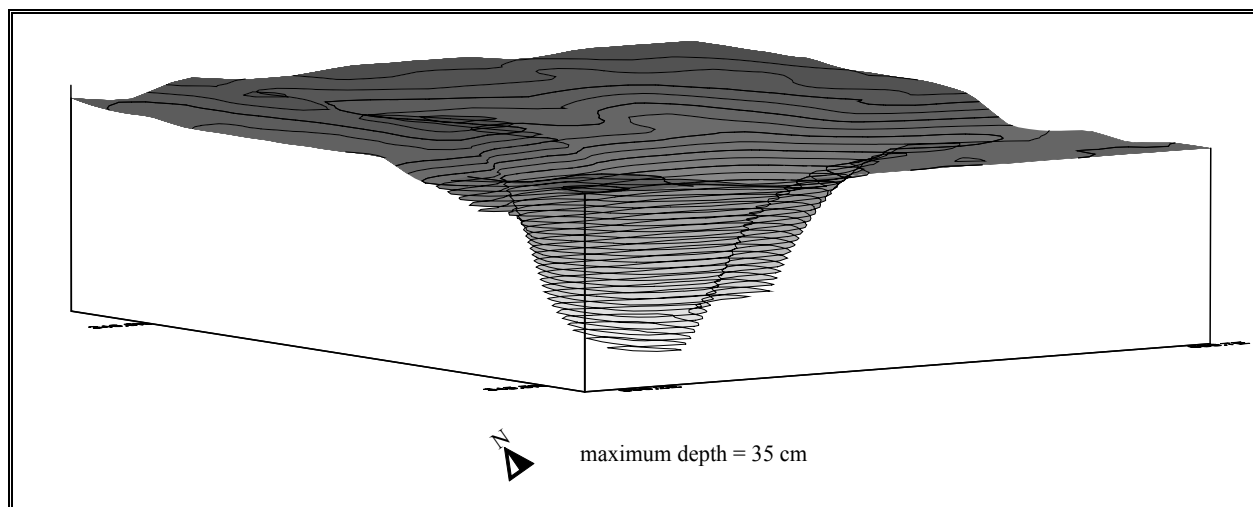


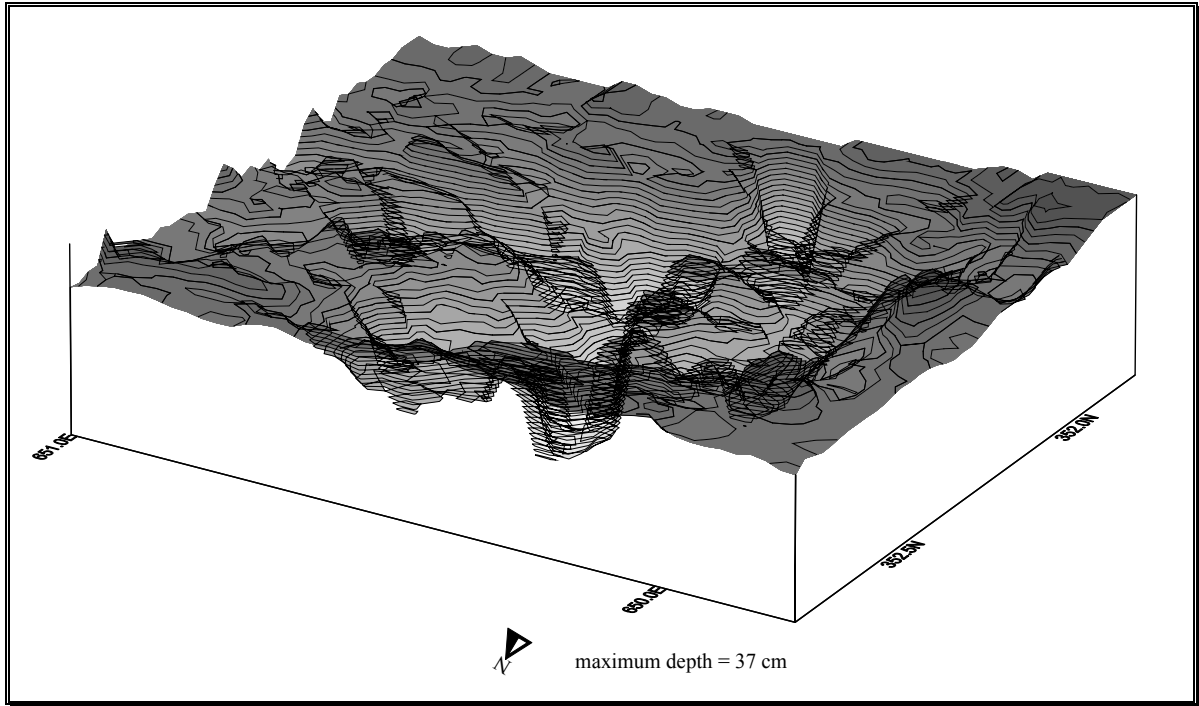
Figure 10.71 SURFER® Generated Topographic Contour Map of BX 7

Another variable plotted three-dimensionally was the location of artifacts. Although not all artifacts from a feature were piece-plotted in the field, Feature 90 had all of its tools, ceramics, and large thermally altered stone (TAS) piece-plotted during excavation. As a result, these data were displayed within the contour plot and illustrated a small part of the overall artifact distribution within Feature 90 (Figure 10.74). Most importantly, the plot illustrated the depth that artifacts, including formal tools and larger TAS, were being found. On a more limited scale, several artifacts were piece-plotted and displayed within Feature 120, a small, deep basin feature.

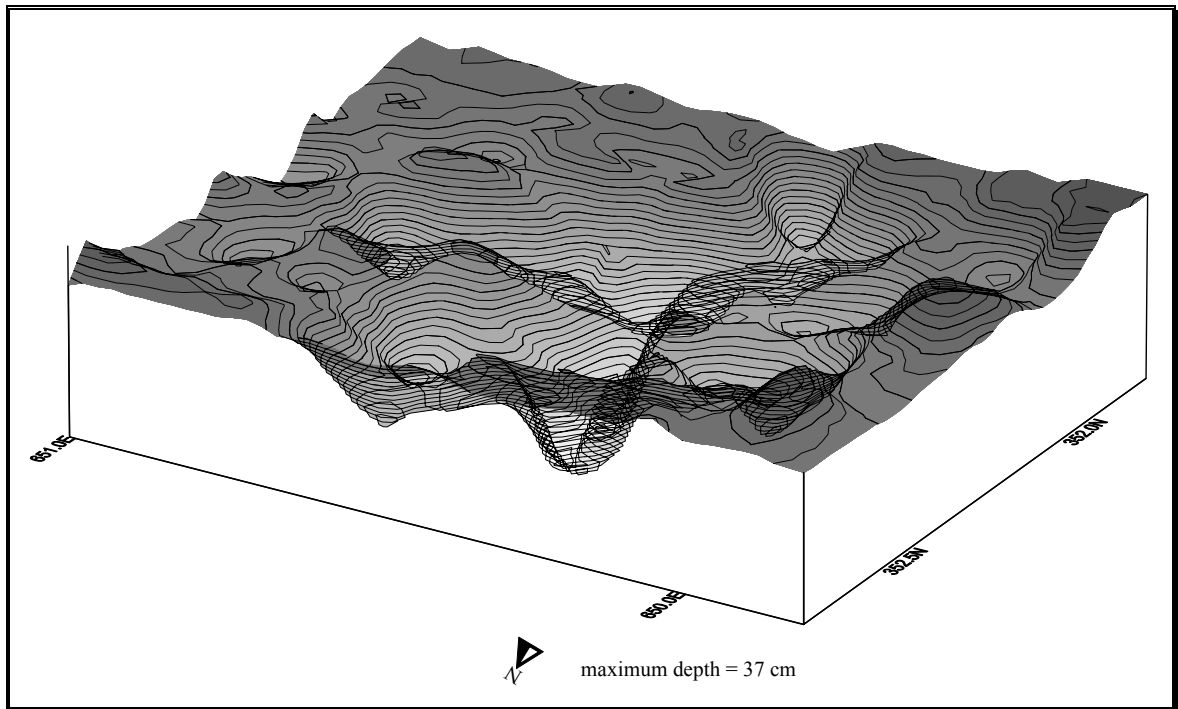
The computer generated contours allowed for a fuller and more detailed depiction of the features at the site, and demonstrated the amount of variability more efficiently than was possible with traditional planviews and profiles. The program also provided insights that could be used in future field excavations to guide the collection of this type of data. First, to enhance the feature reconstruction, more artifacts from within feature contexts should be piece-plotted three-dimensionally for inclusion in the models. As seen in the Feature 90 plot, examining the artifacts displayed within the feature, either along slopes or the edge, could help guide interpretations of feature formation. Another way to improve the consistency of the data and speed its gathering would be the use of a Total Station and data collector. When set from a known datum point, it could provide not only the depth below, but also the x and y coordinates relative to the datum. Such information could also be tied to UTM or State Plane coordinates, which could then aid in inter-site comparisons. The ever increasing availability and sophistication of such technology can only serve to improve both data collection and its analysis.

BASIN FORMATION MODEL

A variety of cultural and natural forces result in ground surface disturbances. Archaeologically, these cultural and natural forces can act independently or in concert to create and shape basin features. To model basin feature formation, a variety of information sources were considered. The Native American ethnographic record was reviewed to identify activities that could have resulted in ground excavations. The literature on natural ground surface disturbances was reviewed and the subsurface tree morphology study and the feature degradation



**Figure 10.72 SURFER® Generated Topographic Contour Map of Feature 56
Demonstrating 2.5 cm Contour Intervals**



**Figure 10.73 SURFER® Generated Topographic Contour Map of Feature 56
Demonstrating 5 cm Contour Intervals**

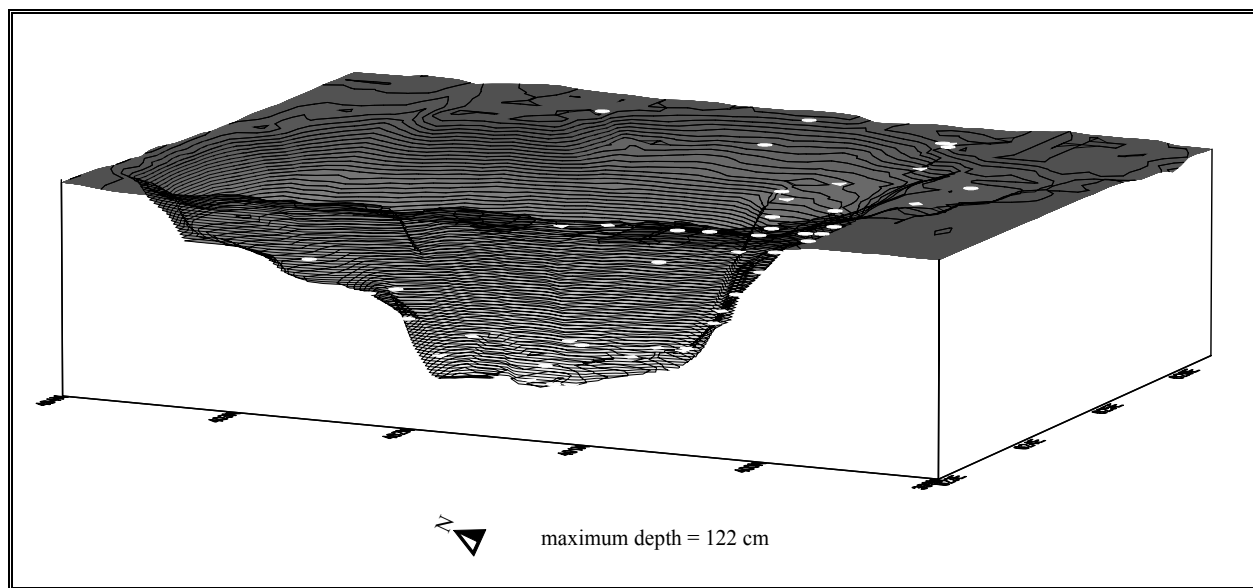


Figure 10.74 SURFER® Generated Topographic Contour Map of Feature 90 with Piece Plotted Artifacts

study were considered. Based on this review, seven basin formational scenarios were conceived. Based on these scenarios, expectations for the Hickory Bluff basin formation were outlined. Basin morphology was examined against cultural forms, tree related forms (tree rots, tree throws), and postdepositional disturbances. Basin content was examined through artifact numbers, geochemistry, and carbonized floral remains. Feature formation at Hickory Bluff was then examined relative to the modeled scenarios and their expectations.

Review of Cultural Ground Surface Disturbances

Historic and ethnographic texts were examined to identify information concerning Native American ground surface excavation practices in the region. While basin features represent a significant portion of the archaeological record, ethnographic and historical documentation detailing ground surface excavation was relatively sparse. However, a review of the regional literature revealed at least six types of ground surface excavations undertaken by Native Americans. These pertain to mortuary function, cooking/food preparation, storage, sweat lodge use, ceremonial activities and habitation construction. A review of the Delaware archaeological literature also produced several commonly applied functional interpretations to specific basin feature types: mortuary use, cooking, storage, and habitation construction (pithouse).

Mortuary Function

Ethnographic Information. Mortuary function is the most commonly referenced use for ground excavations in the ethnographic literature. This is not surprising, as burial customs are more likely to have been recorded by historical observers than mundane activities such as food preparation or storage. Among Coastal Virginia Algonquians, high status individuals were interred in above ground facilities. Common people, however, were buried in the ground, either individually, or in groups (Rountree 1989:113). Descriptions of the construction of burial pits for

commoners include the digging of a deep hole, placing the corpse on sticks in the ground and covering with earth (Smith 1986a:169).

The use of ossuaries, or multiple secondary burials, is well known from an archaeological perspective in the coastal areas of Maryland (Curry 1999). Bodies of deceased individuals would be allowed to decompose, either above ground or in a temporary interment. At a certain time, the bones would be recovered and individuals collectively interred below ground. A late eighteenth century missionary account of the Nanticoke Feast of the Dead described the exhumation of the body after several months, defleshing, and subsequent reburial (Zeisberger 1910:90). Information on the primary interment disposition was lacking. No mention was made of whether reburial took place in an ossuary or individual grave.

Archaeological Information. Several important sites containing human burials have been investigated in the immediate vicinity of Hickory Bluff, offering a broad archaeological view of local mortuary practices. The most important of these sites was Island Field, located at the mouths of the St. Jones and Murderkill Rivers (Thomas and Warren 1970; Custer 1984b; Custer et al. 1990). Documented on the site were a large number of burial features. While the manner of interment varied (i.e., extended, flexed, redeposited and in-situ cremation), the majority were contained in oval to slightly irregular pit features between 1.0 and 1.5 m in greatest dimension (Custer et al. 1990:147-151). Also documented were a number of smaller, apparently intrusive pits and natural disturbances that impacted some of the remains (Custer et al. 1990:147-148). The St. Jones Adena site, located along the middle reaches of its namesake river, contained the remains of approximately 50 individuals (Thomas 1970, 1976). The individual interments represented dry bone cremations as well as secondary interments of disarticulated bone. Multiple individuals were recovered from what appeared to be large shallow pits. These varied in length from 2.1 to 4.8 m, with widths ranging from 2.4 to 3.0 m. Depths extended only 60 to 45 cm below the base of the modern plow zone (Thomas 1976:107). A burial feature was documented at the Carey Farm Site on the St. Jones River just below Dover (Custer et al. 1995b). The burial consisted of a single primary interment within an oval, bowl-shaped basin (Custer et al. 1995b:162).

Cooking/Food Preparation

Ethnographic Information. Native American dietary practices were recorded by early observers in the Chesapeake region. Rountree (1989) effectively summarizes much of this information. Relatively little mention is made of formal in ground cooking facilities, such as roasting pits or earth ovens, although such practices were probably common in the region. Tuckahoe or Arrow Arrum (*Peltandra virginica*) formed a staple in Coastal Algonquian diets (Rountree 1989:53). These tubers had to be processed to rid them of acids before they could be consumed. Rountree describes a process by which these foodstuffs were covered over in the ground and baked for twenty-four hours (Rountree 1989:53). Pehr Kalm, a Swedish traveler, wrote from New Jersey in 1789 describing a similar processing of the tuber in which “they [Indians] gathered a great heap of these roots, dug a great long hole, . . . into which they put the roots, and covered them with earth . . . ; they made a great fire above it, . . . and then they dug up the roots, and consumed them with great avidity” (Fernald et al. 1958:114-115).

Drying and curing by smoking was the only method of meat preservation available to Native Americans. Wood fires can be made to burn generating maximum smoke and low heat by stoking them within ground surface excavations where available oxygen is limited. Such features are often referred to as smudge pits. Other types of fires are also likely to have been set in minor ground surface excavations simply for the practical purpose of delineating a hearth area, and to keep ashes and coals in place.

Archaeological Information. At the Delaware Park site, Thomas (1981) interprets small, saucer shaped basins as possible hearth locations. Custer's (1994) classification scheme of Woodland I features in Delaware defined two varieties of small shallow basins. Feature Types 3 and Type 4 are described as roughly circular to slightly irregular in plan, with a diameter of approximately 1 m. Profiles are shown as having a symmetrical, shallow saucer-like shape. The types are differentiated by maximum depth, with Type 3 described as having an average (plow truncated) depth of 20 cm while Type 4 averages 57 cm (Custer 1994:58). The shallow, saucer-shaped basin form is common across archaeological contexts, and is often interpreted as the remains of hearth/fire pits or food processing facilities.

Storage

Ethnographic Information. Subterranean storage of corn was common in the Piedmont and Great Valley of Virginia and Maryland (Potter 1993:173). In coastal areas, however, more ethnographic information exists regarding above ground storage than storage in subsurface pits (Potter 1993; DeBoer 1988). The differential use of pits, as opposed to above ground storage, figures prominently in investigations of socio-political complexity, particularly in regard to the production and control of corn surpluses (Potter 1993:172-173). Rountree (1989:49) makes some mention of harvested corn being stored in pits; however, the norm in the Chesapeake area appears to have been for corn to be stored in baskets inside houses (Rountree 1989:49, 65) or within special granaries (Potter 1993:45, 172).

A seventeenth century regional account from Virginia describes a variety of material goods buried in a pit in the woods, apparently for safekeeping. The description states that: "[t]heir Corne and (indeed) their Copper, hatchets, Howes, beades, perle and most things with them of value according to their owne estimation, they hide one from the knowledge of another in the ground within the woods, and so keepe them all years, or until they have fitt use for them" (Strachey 1953:115). A similar account from the 1750s records the use of this practice by Kirking Pauley, a Delaware Indian resident near Fort du Quesne at the upper reaches of the Allegheny River. Pauley stored household items in a pit in the woods for safekeeping while he and his family traveled (Browne et al. 1883-1972 37:177).

Archaeological Information. While ethnographic information on subterranean storage in the region is admittedly sparse, archaeological evidence of such practices is more common. At the Delaware Park site, Thomas (1981) identified a number of large pit features which he interpreted as below ground storage facilities based on their regular form and other attributes. Large cylindrical basin features interpreted as formal storage facilities were also identified at the Lums Pond site in New Castle County (Petraglia et al. 1998:83). In Custer's (1994) Delaware feature typology, similar cylindrical pits were classified as Type 5. Large cylindrical pits also were

identified and excavated at the Puncheon Run site located across the St. Jones River from Hickory Bluff (Liebknecht et al. 1997).

While a (food) storage function for cylindrical basin features is inferred, more direct evidence for underground storage was uncovered at the Carey Farm site, where a large cache of argillite bifaces was found (Custer et al. 1995b:166). Also recovered from a bowl-shaped basin feature was a large Mockley vessel (Custer et al. 1995b:164-165). The vessel itself may have been cached below ground in the same manner as the argillite bifaces. It is perhaps equally likely that the vessel contained foodstuffs, perishable products or raw materials that were interred for storage purposes.

Sweat Lodge Use

Ethnographic Information. Ground surface excavations also may have been employed for sweat lodge constructions. A description of a seventeenth century communal sweathouse in Virginia described it as “a Hole” dug in to the riverside “like an Oven” (Banister 1970:45-46). In the center, a cluster of stones was heated in a fire. Other accounts of sweathouses from Virginia, Pennsylvania, and New York similarly describe them as oven-like structures dug into riverbanks (Smith 1986a:168; Wolley 1973). The dimensions of these features were not recorded.

Archaeological Information. Archaeological information on, or precedence for, sweat lodge related ground surface excavation is generally lacking in the region.

Ceremonial Activities

Ethnographic Information. Ground surface excavations also may have been employed in ceremonial practices. Although reported from outside the region, New England Algonquian groups excavated small pits of commemoration at locations of important events (Smith 1986c:462). The story of the event was passed on to others and subsequent offerings were made at the pit. This practice can be seen as similar to the use of altar stones as commemorative offering sites among the Chesapeake Algonquians. The John White late sixteenth century watercolor and derived engraving of a North Carolina Algonquian village of Secota shows a ceremonial area or “dance circle” ringed by large effigy posts set in the ground.

Archaeological Information. Direct archaeological evidence for ceremonial activity related ground surface disturbance is generally lacking for the region. It should be noted, however, that the traces of such activities would very likely mimic those of strictly economic ones and would be therefore be difficult to distinguish.

Habitation Construction (Pithouses)

Ethnographic Information. The construction and use of semi-subterranean structures and dwellings was relatively common among North American Indians, particularly in areas of more extreme climate. In general, ethnographic references to semi-subterranean house construction are lacking for the coastal Mid-Atlantic.

Archaeological Information. In Delaware, the archaeological interpretation of large basin features representing semi-subterranean structures is currently in debate.

Basin Formation Scenarios

To examine the various forces and events that could potentially result in basin formation, seven scenarios were constructed. These scenarios incorporated both natural and cultural causal forces, both individually and in various permutations.

Scenario 1 - Cultural Formation, Single Episode Excavations

This model of basin formation pertains to singular cultural events such as the excavation of a pit by site occupants for a specific purpose (Figure 10.75). Such features may have been deliberately back filled or left to fill in naturally. This scenario is perhaps the least common as it is predicated on the original ground excavation having had a single use life and then remaining unaffected by postdepositional forces or events.

Initial State. Cultural ground surface excavation

Cultural Interactions. Backfilled

Natural Interactions. Natural infilling

Expectations. Certain cultural ground surface disturbances such as cylindrical basins, can be expected to show pronounced signatures. Morphological attributes such as straight walls and flat bottoms would provide clear cultural signs. Other archaeological entities, such as bell-shaped pits also may be designed and shaped by humans. In general, straight lines, flat planes and right angles are rarely found in nature. These forms, expressed either in the morphology of a specific feature, or in spatial patterning of multiple entities, are the direct result of human input. Purposely constructed ground surface excavations can be expected to contain directly or indirectly collected organic material associated with the site occupation. This would leave specific geochemical traces, such as elevated presence of certain elements or modification of soil pH. Elevated artifact counts are seen as a strong indicator of a cultural association. However, low artifact volumes are not necessarily viewed as a negative indicator for a cultural association, as this might be the result of a specific, deliberate on-site behavior(s).

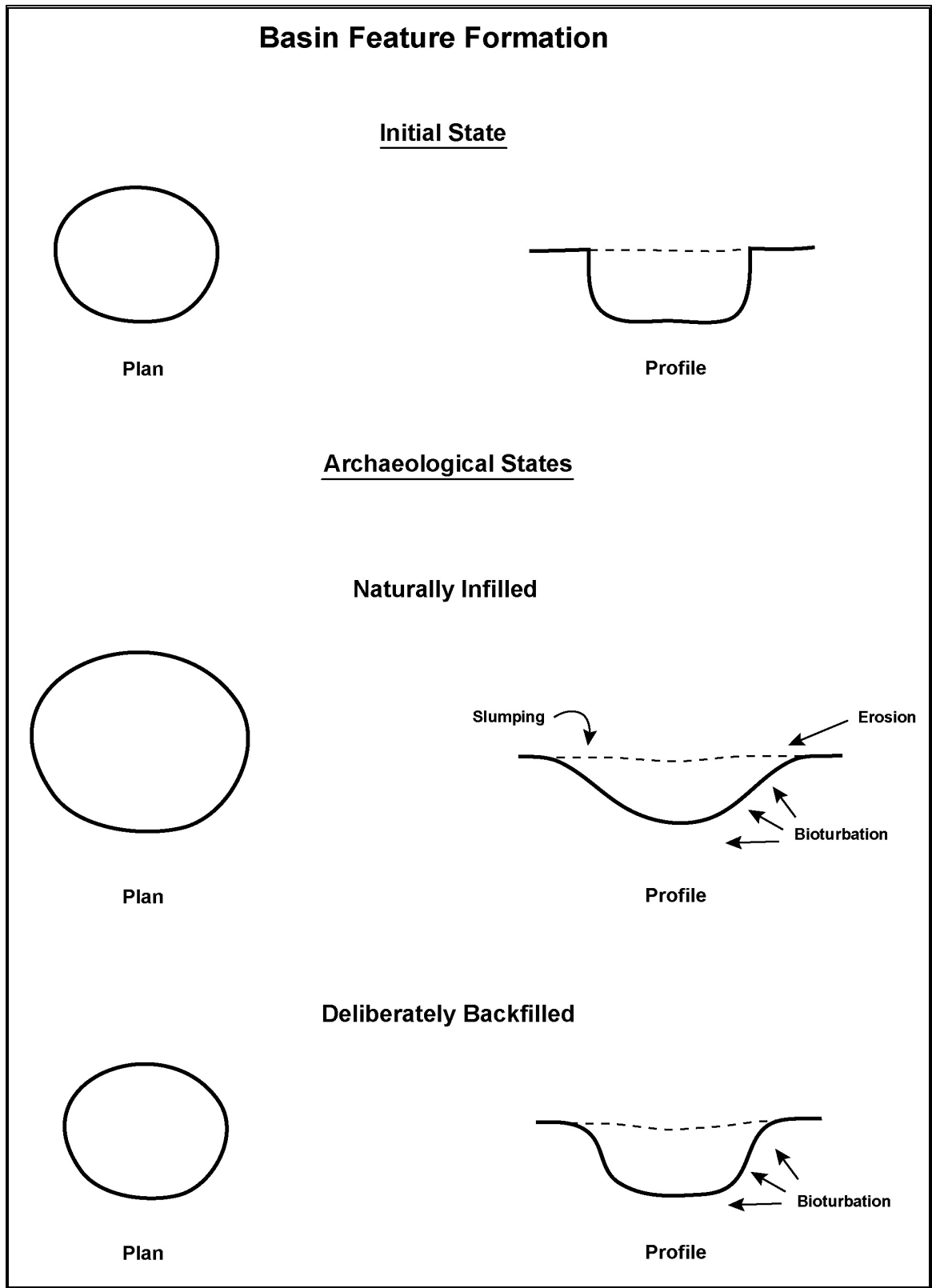
Scenario 2 - Cultural Formation, Multiple Episode Excavations

The types of cultural ground surface disturbances articulated in Scenario 1 can be expected to be reused, altered or otherwise modified throughout the occupation of the site. In addition, original, remnant ground surface disturbances may have been opportunistically re-utilized during a later site visit (Figure 10.76). Such events would clearly alter the original morphology of a basin entity and make its formation difficult to assess from an archaeological perspective.

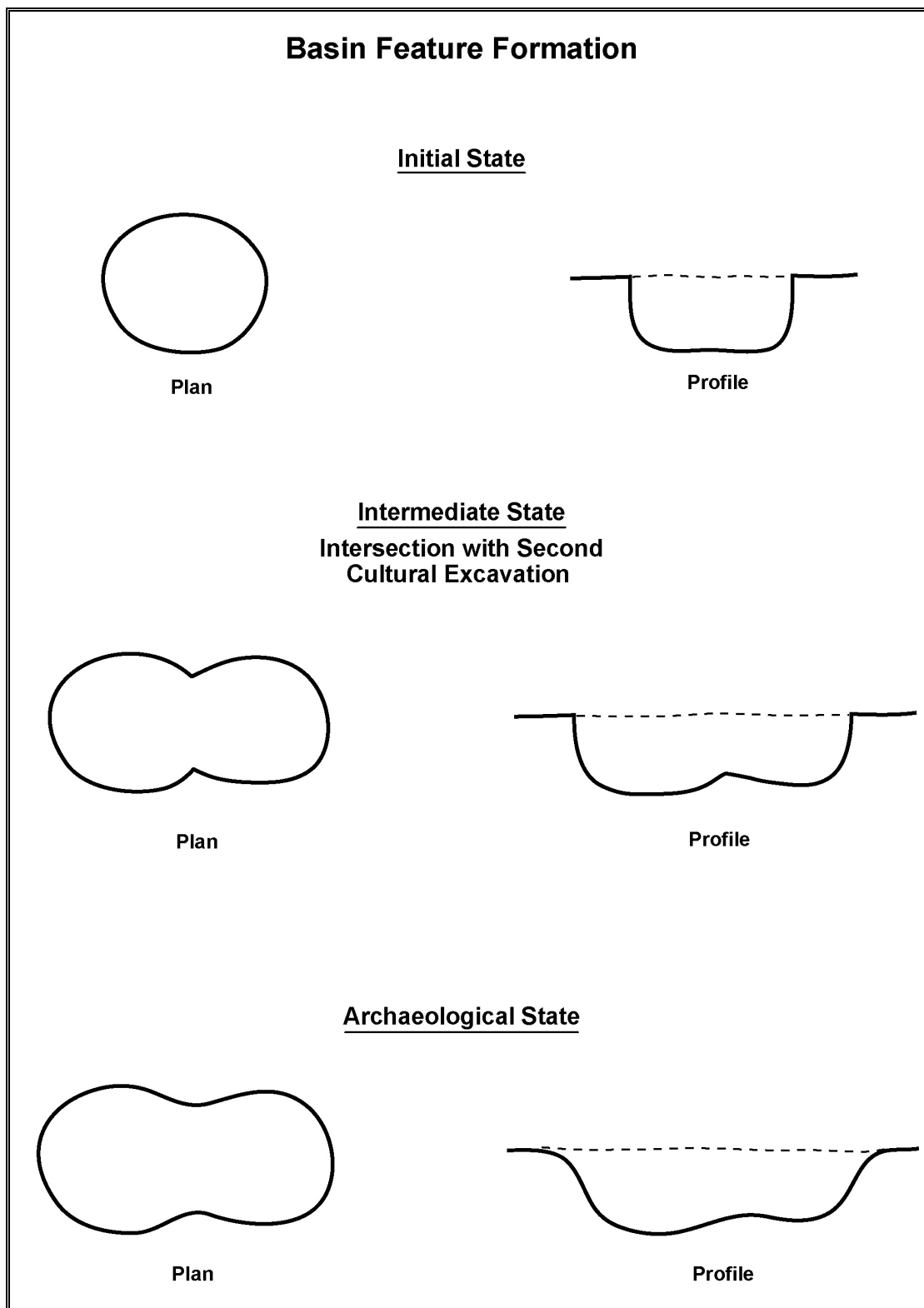
Initial State. Cultural ground surface excavation

Cultural Interactions. Intersecting ground surface excavations

Natural Interactions. None



**Figure 10.75 Basin Feature Formation Scenario #1 Cultural Formation:
Single Episode Excavation**



**Figure 10.76 Basin Feature Formation Scenario #2 Cultural Formation:
Multiple Episode Excavation**

Expectations. Multiple episode ground surface excavations may be more difficult to recognize as distinctly cultural in origin. These multiple, or modified excavations, are expected to retain some morphological attributes that may be recognizable as cultural. The same expectations for geochemical traces and artifact data apply as in Scenario 1.

Scenario 3 - Cultural/Natural Formation, Cultural Excavations Intruded by Natural Disturbances

This category postulates that the cultural ground disturbances may interact with various combinations of natural postdepositional agents (Figure 10.77). Natural agents such as roots and burrowing animals seek out softer, less consolidated soils found in cultural features. Roots of deciduous tree are particularly adept at seeking out softer soils (Farb 1961). Consequently, few archaeological features of any significant age can be expected not to have been impacted to some degree by natural agents, and consequently this scenario of basin formation process is likely to be widely represented.

Initial State. Cultural ground surface excavation

Cultural Interactions. None

Natural Interactions. Disruption by biotic disturbances; bioturbation

Expectations. In cases of specific basin features that can clearly be ascribed a cultural origin, natural disturbances such as root or rodent channels are expected to be distinguishable by their contrasting morphologies (i.e., obvious root channels), providing the natural (biotic) disturbances do not fully mask the cultural basin form.

Scenario 4 - Cultural/Natural Formation, Cultural Excavation of a Natural Disturbance

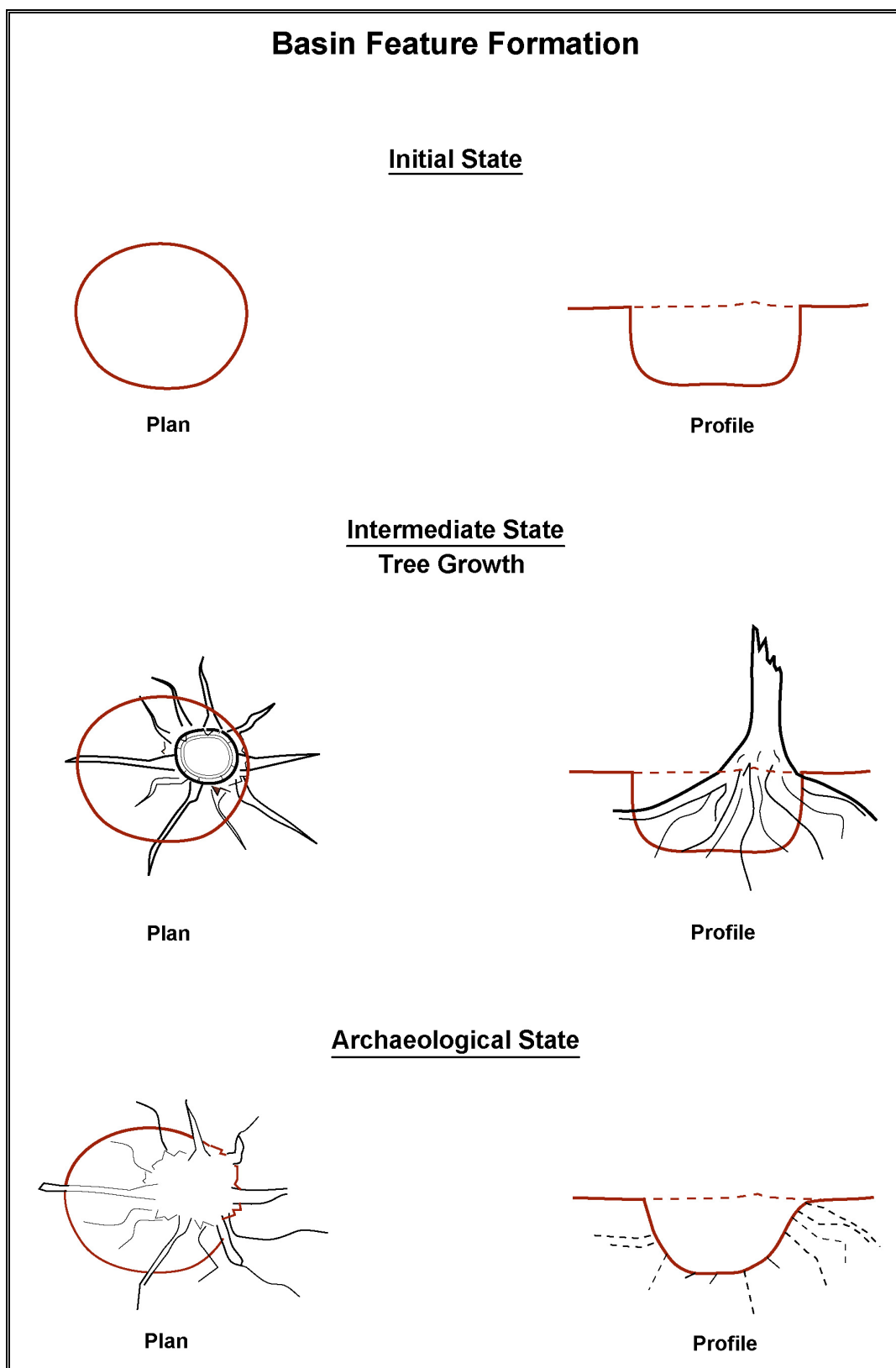
Humans are no less inclined to exert more effort than necessary than are plant roots or burrowing animals (Figure 10.78). Human excavation or re-excavation of a variety of natural on-site disturbances could therefore be expected. Pre-existing disturbances such as tree rots, tree throws and other natural depressions are likely to have been enlarged/modified by the site occupants for a variety of purposes. In either scenario, the formation of the basin is postulated as having been the result of cultural and natural forces acting in concert.

Initial State. Natural ground surface disturbance

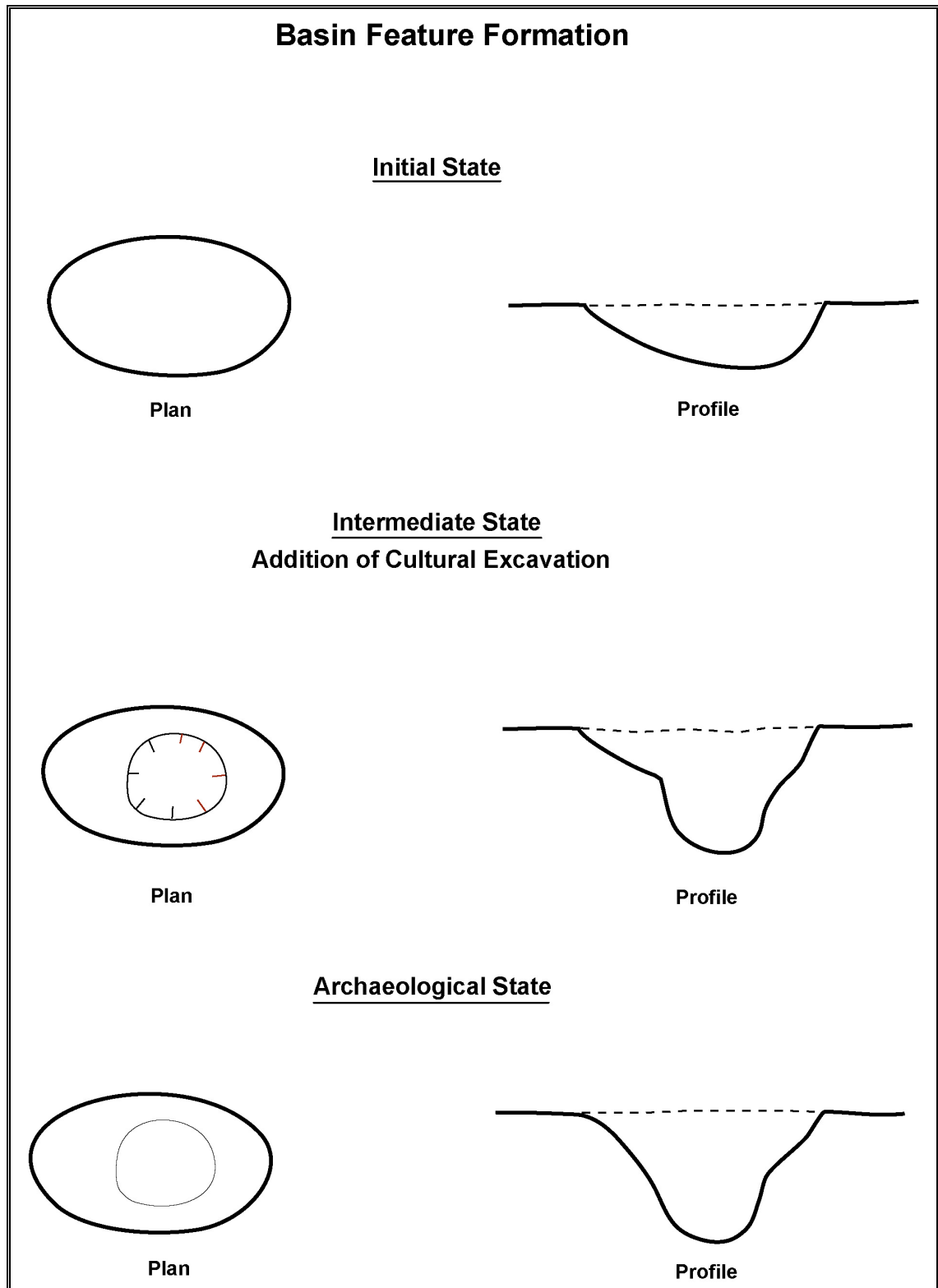
Cultural Interactions. Excavation

Natural Interactions. Bioturbation

Expectations. Basin features resulting from cultural modification of a natural entity can be expected to show morphological attributes of both natural and cultural disturbances, providing that the cultural excavation does not fully mask the morphology of the original disturbance. While the morphologies of such features may not be easily decipherable, a cultural use of a pre-existing ground surface disturbance is likely to leave geochemical signatures very similar to that of pure cultural features. Significant elevation in relative artifact counts could also be seen as a strong indicator of cultural use.



**Figure 10.77 Basin Feature Formation Scenario #3 Cultural and Natural Formation:
Intruded by Natural Disturbances**



**Figure 10.78 Basin Feature Formation Scenario #4 Cultural and Natural Formation:
Cultural Modification of Natural Disturbance**

Scenario 5 - Cultural/Natural Formation, Cultural Utilization of Natural Disturbances

Certain ground disturbances that were originally purely natural in origin were likely to have been utilized for cultural purposes (Figure 10.79). Ground disturbances such as tree throws, or in the case of sloping areas, wash gullies, and other erosional features, would have offered convenient locations for refuse disposal. Although the ground disturbances were natural in origin, and may have remained unmodified, the deliberate addition of artifacts would make their archaeological manifestation cultural in association. This scenario should be considered when evaluating the possible formation/use of any large basin entity, particularly when elevated artifact numbers of artifacts are recovered.

Initial State. Natural ground surface disturbance

Cultural Interactions. Deposition of artifacts

Natural Interactions. Bioturbation

Expectations. The morphology of the ground disturbance would be strictly that of a natural disturbance (e.g., tree rot, tree throw). Primary evidence of a cultural component can be expected to consist of elevated artifact counts resulting from use of the disturbance for refuse disposal. Such use can also be expected to leave geochemical traces. Similarly, the recovery of an absolute date from a basin context that is coeval with a known occupation period would indicate that the ground surface disturbance was open during that time.

Scenario 6 - Natural Formation

Examples of ground disturbances that could result from purely natural processes include root disturbances, rodent channels, tree throws, tree rots and anomalies generated by freeze/thaw cycles, erosional events or through ongoing soil development (Figure 10.80). In general, recent naturally caused ground disturbances are easily discriminated from potential cultural features by the presence of observable organic materials, soil voids, and other attributes. Disturbances of greater age can be significantly more difficult to discern due to decomposition of organic material, settling of the fill, and bioturbation of the interface with the undisturbed soil matrix. These factors can potentially work together and cause natural disturbances to mimic the properties of cultural features. The phenomenon of accelerated soil development, which can occur in both natural and cultural disturbances as a result of enhanced groundwater movement, must also be considered (Section 9.0). In this scenario, E-horizon development within a very old natural disturbance could potentially cause the fill to closely resemble that of cultural features. Similarly, nascent B-horizon development along the lower margins of a natural disturbance, again facilitated by enhanced groundwater movement, could cause these areas to become more firm and therefore, more closely resemble the form of a cultural entity. In fluvial settings, flood scours that subsequently filled in with organic-rich alluvium, when viewed archaeologically, could also mimic cultural ground disturbances.

Initial State. Natural ground surface disturbance

Cultural Interactions. None

Natural Interactions. Bioturbation

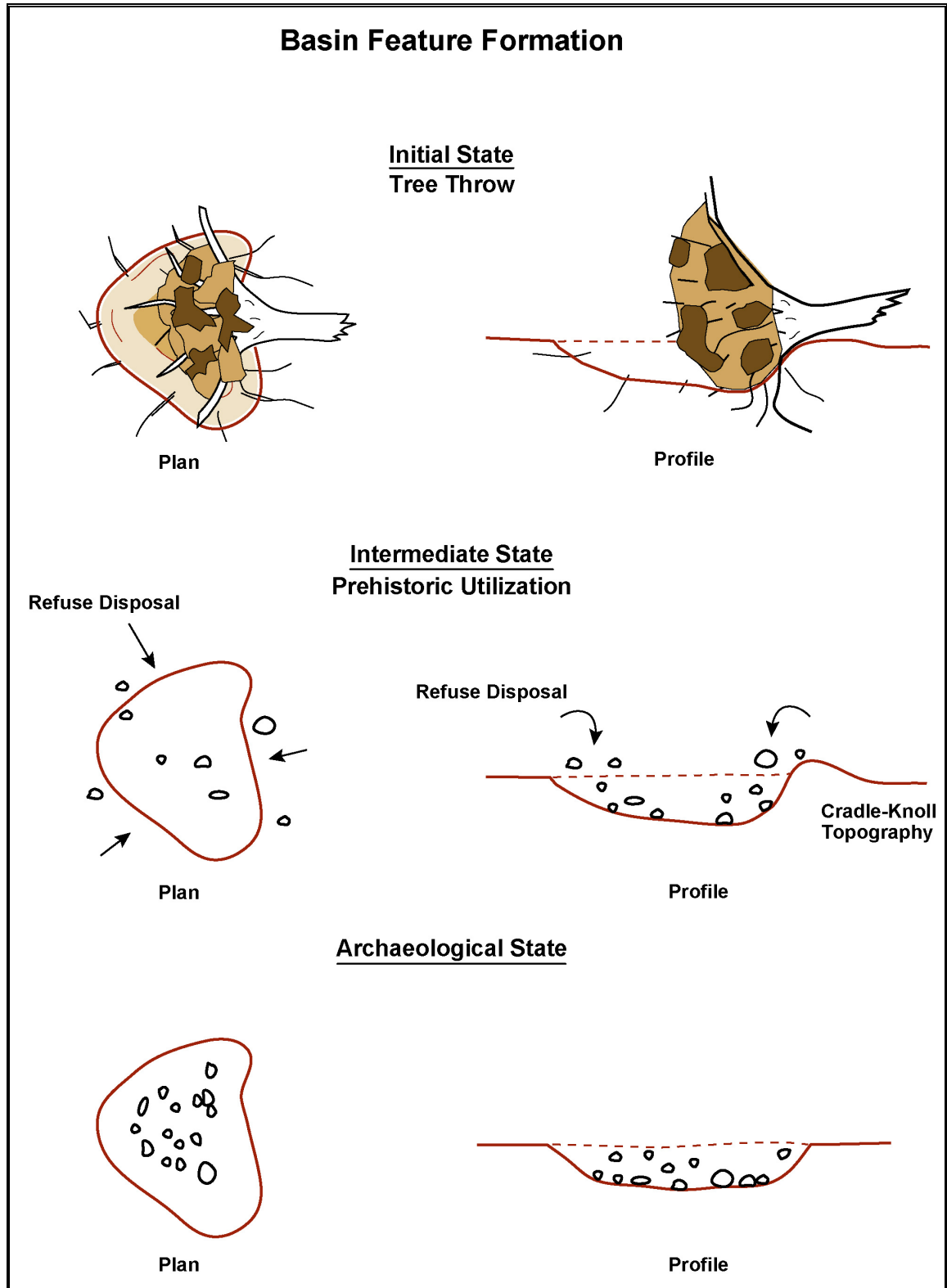
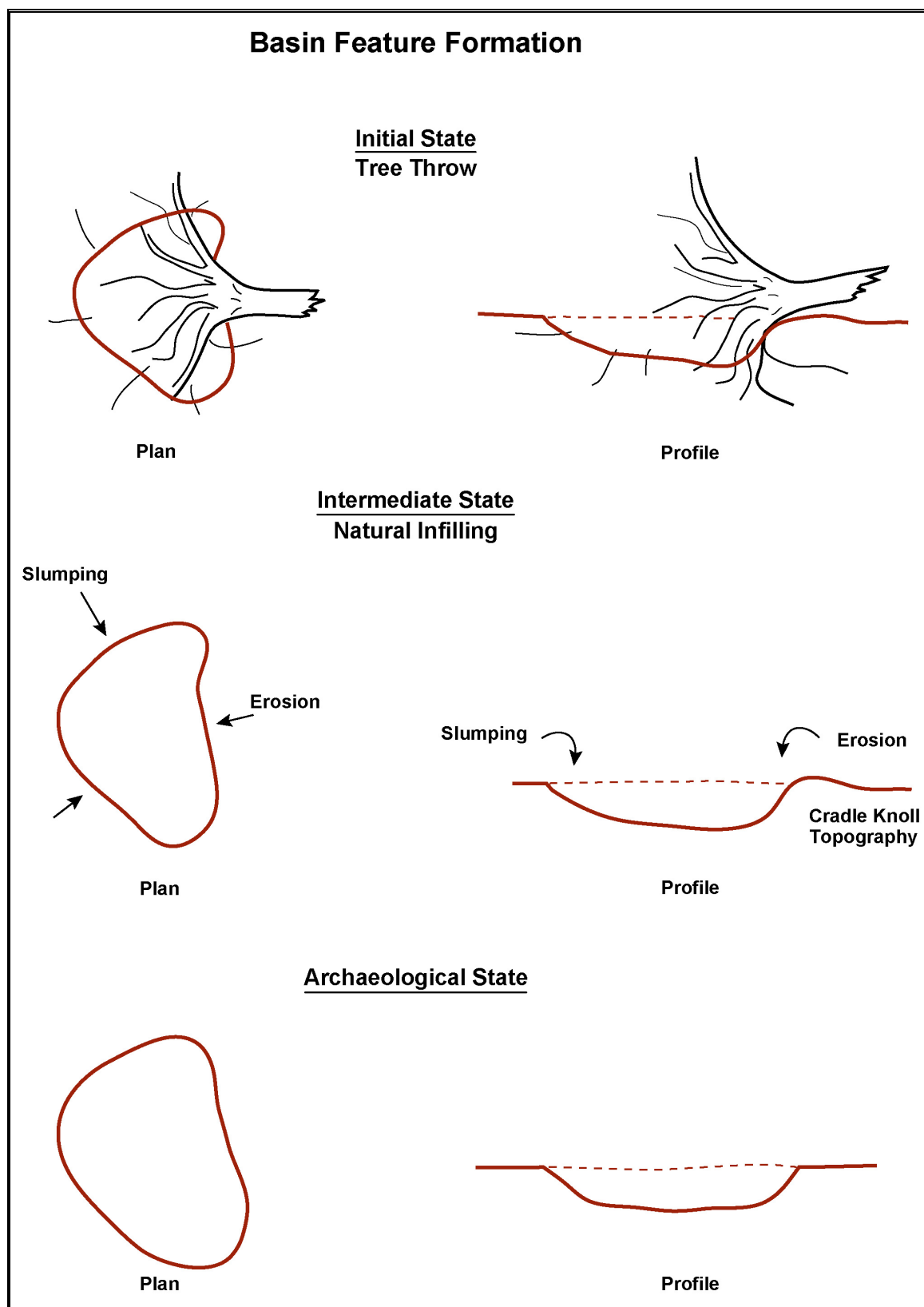


Figure 10.79 Basin Feature Formation Scenario #5 Cultural Utilization of a Natural Disturbance



Expectations. One finding of the subsurface tree morphology study was that in all the examined specimens, recognizable below grade disturbances associated with the tree/root mass were shallow. As recorded, these rarely penetrated the base of the E-horizon or exceeded a depth of 50 cm. Tree roots are known to radiate away from the trunk a distance equivalent at least to the spread of the crown (Farb 1961:94). These roots constantly branch and re-branch with distance from the trunk. Within a short distance from stump, the mass of the root system becomes essentially inconsequential in relation to the volume of soil through which it grows. The only appreciable concentration of root mass is present immediately below and around the base of the trunk (root ball). As the living tree bisection demonstrated, even directly under the tree location, the actual mass of the root system is relatively limited. The subsurface tree morphology study findings detailed how the root ball, or the concentration of roots radiating out from the base of the stump, leaves a shallow, restricted void as the tree remnants decompose. More peripheral roots were demonstrated as leaving only individual holes or divots, representative of linear disturbances (individual root channels) radiating out and away from the central core. Tree mold related entities, therefore, would be anticipated to exhibit only a shallow, saucer-like shape where the root ball decayed. Larger root casts would be expected to give the basin sides an irregular contour. Former voids left by smaller diameter roots radiating further away from the stump are unlikely to be archaeologically recognizable.

The archaeological documentation of modern tree throws as part of the subsurface tree morphology study proved useful in modeling archaeological expectations. The study encountered the oval to crescentic to D-shaped planviews typically described for tree throws (Langhor 1993). However, the archaeological documentation of tree throws demonstrated that the ground surface disturbances associated with the downing of even very large trees can be quite shallow. Archaeological manifestations of tree throws can be expected to exhibit similar size parameters as contemporary examples. The cradle and knoll morphology, demonstrated by various tree throw studies (Stephens 1956; Beke and McKeague 1984; Cremeans and Kalisz 1988), was observed in the study. This morphology is precipitated by the upward displacement of soils as roots are pulled from the ground. The ongoing process of the redeposition of the displaced soils back into the tree throw void was also observed in the field. This violent displacement and subsequent redeposition of portions of the soil column is expected to be reflected in the composition of the filled in ground surface disturbance. These fill characteristics (i.e., subsoil mottling, displaced gravel) are expected to be archaeologically recognizable, even in tree throws of some antiquity.

Scenario 7 - Culturally Induced Natural Events

This scenario of basin formation pertains to human input of what otherwise would be thought of as a purely natural event (Figure 10.81). A hypothetical example of this could be a culturally induced tree fall. In this scenario, a combination of grubbing and burning at the base of a large tree is utilized to sever a large portion of its root system causing it to fall. The resulting ground disturbance would be the result of both human input (digging, burning) and that of what is normally considered to be a natural event (tree fall).

Initial State. Natural ground surface disturbance

Cultural Interactions. Grubbing and burning

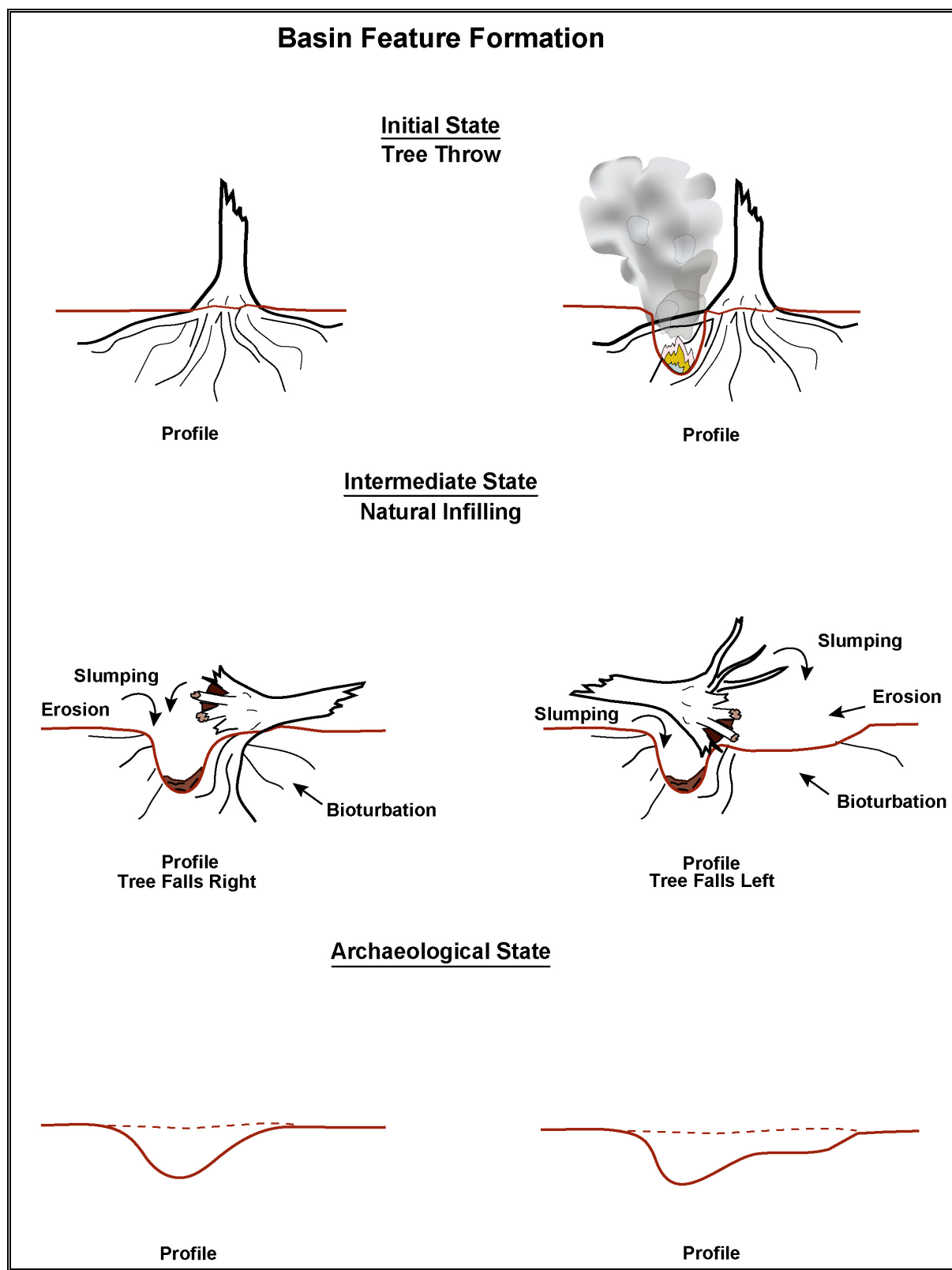


Figure 10.81 Basin Feature Formation Scenario #7 Cultural Formation

Natural Interactions. Bioturbation

Expectations. Basin formation may be the result of a culturally induced tree fall. It is postulated that a (crescentic) trench was excavated along one side of a mature tree, digging around the major root members. The exposed roots would be severed by constructing a fire within the excavation. This would have the effect of both killing the tree and making it unstable. The purpose of such activity would be to clear areas for habitation, down trees for limb fire wood, enhance growth of economically valuable trees such as mast-bearing species by eliminating competition, promote wild food producing plant species and/or semi-domesticates, or any combination of these impetuses. In terms of resultant ground surface disturbance morphology, archaeological expectations are twofold. Should the tree have fallen in the direction away from the trench, then the only archaeological manifestation would be the grubbing trench. If the tree fell in the direction of the trench, then a three throw-like disturbance where the roots pulled up with the trench in one end would be expected (Figure 10.78). Either morphology can be expected to have been subjected to the postdepositional forces and changes articulated in the previous scenarios. Artifact content would be contingent on occupation specific behavior and the ground surface disturbance's location in relation to the core of the site occupation. However, as such landscape modification activities would be expected to have been undertaken some distance away from the habitation center, limited artifact numbers could be expected for basin formation.

BASIN FEATURE ANALYSIS

Methodology

A total of 108 basin features were identified on Hickory Bluff. In addition, 20 archaeological ground surface disturbances encountered on the site could confidently be assessed as tree molds. As this feature assemblage was far greater than could be studied in full, a representative sample was selected (Table 10.4). The set included five examples each of the large basin (B-1), medium basin (B-2) and small basin (B-3) types. These were defined as larger than 2 m in greatest dimension (B-1), between 1-2 m in greatest dimension (B-2), and less than 1 m in greatest dimension (B-3). Basin features were selected for the study sample based on a number of criteria, including completeness of excavation and lack of gross physical overlap with recent natural disturbances. The availability of geochemical and absolute dating data was also considered. A total of five archaeologically investigated tree mold features (D-2) were also analyzed for comparative purposes.

Table 10.4 Selected Basin Features by Type

B-1 Features	B-2 Features	B-3 Features	D-2 Features
2, 77, 90, 118, 169	3, 67, 13, 234, 298	4, 116, 120, 202, 267	20, 63, 119, 126, 314

The morphology of the basin features in the study set was first compared to known subsurface tree and tree throw morphologies. Evidence for a biological component to the basin formation, such as large scale root or rodent intrusions, was assessed. Evidence for cultural morphology was examined. Artifact data, specifically counts relative to adjacent non-feature contexts, were evaluated as potential cultural signatures.

Large Basin Feature Descriptions

Five large basins were selected for analysis. These were Features 2, 77, 90, 118 and 169. These features exhibited a distinctive oval to crescentic to D-shaped planview. In profile, these features generally showed one steeply sloping side and one shallow sloping, or flaring side. This specific D-shaped large basin form was replicated in the Experimental Feature Degradation Study (XF 1 and XF 8).

Feature 2. This large basin feature was roughly ovoid in plan. The profile showed moderately sloping walls and a undulating base. Fill was distinguished from the undisturbed soil by a finer texture, slightly darker color, and the presence of charcoal flecking. Dimensions were recorded as 3.90 x 2.54 x 1.15 m. The feature fill was subjected to extensive geochemical analysis. An AMS date of 2790+/- 40 years before present (B.P.) was obtained from the basin.

Feature 77. In planview, the exact configuration of Feature 77 remained unclear as its periphery was truncated on two sides by additional basin features. In profile, the feature clearly showed one steeply sloping side and one more gently sloping side that met at a rounded bottom. The below grade contour can be extrapolated to approximate an irregular sub-ovoid. Fill soils were finer in texture than the undisturbed matrix. Some mottling of subsoil was noted therein. Minor charcoal flecking was also present. Minimum greatest dimensions were 3.30 x 2.50 m with a depth of 1.32 m. Fill was subjected to geochemical analysis.

Feature 90. Feature 90 was elliptical to oblong in planview. One wall sloped steeply and the other at a more shallow angle. Dimensions were recorded at 4.60 x 2.65 m with a maximum depth of 1.22 m. The deepest portion of the feature showed a bluntly rounded contour. Fill was slightly, but discernibly, darker than the surrounding soils. An AMS date of 4070 +/- 40 years B.P. was obtained from the basin. The feature fill was subjected to geochemical analysis.

Feature 118. Feature 118 was an irregular semi-elliptical feature recorded in the plowed, southeastern periphery of the site. One wall sloped steeply to a rounded bottom while the other sloped at a shallower angle. Minor charcoal flecking was present throughout the fill. Dimensions were 3.00 x 1.10 m with a depth of 0.78 m.

Feature 169. Feature 169 was D-shaped in planview. Side walls were steep. The uppermost portion of the feature was truncated by excavation of another medium basin feature, so its full configuration remained undetermined. Walls sloped steeply to a rounded bottom. Fill was slightly darker than the undisturbed matrix soils. Minor charcoal flecking was also noted. Maximum dimensions were recorded as 3.40 x 1.65 m with a depth of 1.12 m. The feature fill was subjected to geochemical analysis.

Medium Basin Feature Descriptions

In contrast to the large basin variety, the medium basins exhibited greater morphological variation, at least in profile contour. Geochemical analysis was not conducted on any of the medium basins. The sample selected for study consisted of Features 3, 67, 139, 234, and 298.

Feature 3. Feature 3 intersected with another basin feature, making its exact plan configuration difficult to establish, although the identified portion was sub-ovoid in shape. Walls

of the uninterrupted portion sloped steeply to a flat bottom. Fill was slightly darker and finer textured than the undisturbed soil matrix. Dimensions were recorded at 1.27 x 1.05 m with a maximum depth of 0.65 m. Feature 3 did not contain elevated numbers of artifacts in relation to adjacent non-feature contexts. Two separate AMS dates were obtained from the feature: 2600+/-60 years B.P. and 2790+/-60 years B.P.

Feature 67. This feature was very regular in form. In planview, the feature was sub-ovoid in shape. In profile, the basin was bilaterally symmetrical with steep walls and a nearly flat bottom. Fill was slightly darker and finer textured than the surrounding soils and minor amounts of charcoal flecking were noted. Dimensions in plan were 1.20 x 1.00 m, with a depth of 0.34 m.

Feature 139. Feature 139 was oval to irregular in planview. Walls sloped steeply to a rounded bottom. Planview dimensions were recorded at 1.36 x 0.84 m, with a depth of 0.66 m. Fill soils varied from the other basins in that they were notably coarser or sandier than the surrounding undisturbed matrix.

Feature 234. In planview, Feature 234 was oval to slightly irregular in form. The Feature 234 fill was essentially the same as Feature 1 and consisted of a sandy loam that was slightly darker in color than the adjacent E-horizon. In profile, the feature was essentially symmetrical with steeply sloping sides and a bluntly rounded bottom. Planview dimensions were recorded as 1.72 x 1.20 m, with a depth of 0.48 m below the base of Feature 1.

Feature 298. Feature 298 was roughly oval to irregular in plan although its exact configuration was difficult to ascertain. The south and west portions of the feature bottomed out quickly against a natural rise in the C-horizon sands. The north and west portions of the feature were indistinct and difficult to define archaeologically. The feature fill was siltier and retained more moisture than the adjacent C- and E/C-horizons. Small artifacts were recovered, mostly from the deeper, middle portion of the feature. Sidewalls sloped shallowly to a wide gently rounded base. Maximum dimensions were 1.72 x 1.34 m, with a depth of 0.30 m.

Small Basin Feature Descriptions

Small basins were defined as having a maximum plan dimension of less than one meter. In general, these features were often quite regular in form, exhibiting a circular to slightly oval configuration. Profiles, however, varied considerably both in dimension and configuration. Geochemical analysis was not performed on any of the small basin examples. Small basins chosen for study were Features 4, 116, 120, 202, and 267.

Feature 4. Feature 4 was essentially cylindrical in shape with very steep sides and a bluntly rounded bottom. Fill soils were typical of basin features in that they were very slightly darker and finer textured than the surrounding soils. The feature yielded an AMS date of 1540+/-50 years B.P. Maximum dimensions were 0.42 x 0.37 m with a depth of 0.92 m.

Feature 116. This feature was oval to irregular in plan. One wall sloped at a steep angle while the other one had a shallower pitch. A portion of the base was flat, while the other side appeared to be interrupted by a rodent burrow. The fill was consistent with that of other basins; it was very slightly darker than the surrounding undisturbed matrix and contained minor amounts of charcoal flecking. The feature dimensions were 0.47 x 0.42 m with a depth of 0.12 m.

Feature 120. In profile, Feature 120 exhibited a deep, shaft-like configuration. The feature orifice was oval in plan. The walls, however, were nearly vertical to a depth of at least 95 cm. The feature dimensions were 0.75 x 0.40 m in planview. Four separate fill strata were defined. The upper two strata yielded relatively large numbers of artifacts including five Wolfe Neck and three Hell Island ceramic sherds. Also recovered were calcined bone and carbonized hickory nutshell and wood. A wood charcoal fragment from Stratum I yielded an AMS date of 920+/-50 years B.P. The lowest stratum (IV) did not yield any artifacts. The unconsolidated soils interfaced with the upper portions of the C-horizon sands, making the bottom of the basin unrecognizable.

Feature 202. This feature was unique on the site. It consisted of a small bowl-shaped basin measuring 36 x 34 cm. The rounded bottom extended to a depth of 15 cm. Feature 202 contained artifacts in a configuration strongly suggestive of deliberate placement. A set of cobble tools was found at the bottom of the feature and large ceramic sherds were used to line portions of the basin walls. A large quartzite cobble capped the feature. The fill characteristics were consistent with the majority of basins on the site with soils only very slightly darker than the surrounding undisturbed matrix. Minor charcoal flecking was also present.

Feature 267. Feature 267 consisted of a small basin identified within Feature 129, a large shallow basin. Feature 267 was slightly oval in plan and measured 0.35 x 0.29 m. Walls were steep and well defined. The bottom was rounded and firm. Soils were slightly coarser (sandier) and lighter in color than the Feature 129 matrix. Two carbonized nut hulls and two small TAS fragments were recovered from within the small feature.

Tree Mold Feature Descriptions

Five archaeological tree molds (D-2) were selected for this analysis. These natural features consisted of Features 20, 63, 119, 126 and 134. The documentation of these disturbances was used to augment the finding of the Subsurface Tree Morphology study.

Feature 20. Feature 20 was oval to slightly irregular in plan. Dimensions were recorded at 0.39 x 0.60 m. Walls were steep and straight sided with some apparent root casts present. In profile, the feature was slightly conical in form, although the base of the feature extended past the excavation limits of 0.60 m.

Feature 63. This feature was determined to have been a tree burn location. The feature was delineated in planview as a broad, but amorphous area of discolored soils. Present within this area were numerous small patches of more strongly reddened (oxidized) soil and masses of charcoal. Linear pockets of loose and/or charcoal flecked soil, apparently representing root channels, were noted throughout. The area of discolored and disturbed soil measured 1.90 x 1.35 m, with a depth between 0.24 and 0.28 m.

Feature 119. This feature consisted of a shallow, saucer-like disturbance. The feature was slightly irregular both in profile and planview. Dimensions were recorded at 0.50 x 0.45 m with a depth of 0.12 m.

Feature 126. Feature 126 was identified in the plowed portion of the site. The feature was highly irregular in outline, with a number of linear disturbances radiating outwards from the

central core. The core measured approximately 0.28 x 0.15 m with a depth of 0.29 m. Fill was darker and siltier in texture than the surrounding undisturbed soils.

Feature 314. Feature 314 was not identified in planview. The profile undulated strongly, having variable steeply sloped to gradually tapering side walls. Numerous apparent root channels radiated from and undercut the main body of the feature. As a result, its exact morphology was difficult to ascertain. Plan dimensions were recorded at 0.82 m by undetermined width (excavated width was 8-10 cm). Maximum depth was 0.64 m.

Analysis

The features were analyzed by comparing feature attribute data with the attribute variables presented in the basin formation scenarios and expectations. The attributes were grouped in two categories: basin morphology and basin content. Basin morphology was assessed in terms of known cultural morphologies, known tree related morphologies (tree rot, tree throw), and evidence for postdepositional changes. Basin content was examined relative to artifacts, geochemistry and absolute dating.

Basin Morphology

Cultural Morphology. A total of four basins, Features 4, 67, 202 and 234 exhibited morphologies highly suggestive of a purposeful cultural construction. Feature 4 was the most distinctive. This small basin feature exhibited an essentially cylindrical form. Feature 202, also a small basin, exhibited a very regular, bilaterally symmetrical plan and profile. Profile was bowl-shaped while the planview was almost circular. Feature 67, a medium basin, exhibited a similarly regular and symmetrical form together with a nearly flat (level) bottom. Medium basin Feature 234 also exhibited a very regular, deep bowl-like shape. The remaining features did not exhibit morphologies that could be considered entirely the result of a cultural formation.

Tree Related Morphology. Four of the five known tree mold features consisted of a shallow depression from which numerous linear disturbances were seen to emanate. The sides of these features were irregular and indistinct. The fifth tree mold, Feature 20, exhibited a narrow outline and deep tapering profile consistent with observed pine tree stump/tap root molds.

Two basins, Feature 298 and Feature 116, exhibited strong tree like attributes, based on findings of the Subsurface Tree Morphology Study (i.e., shallow, saucer-like forms and irregular, diffuse sides/edges). Feature 116 exhibited linear disturbances extending outwards from the main body of the basin. In form and dimension, this feature was very similar to the archaeologically documented tree molds. Feature 298 was much larger in area but also had a shallow rounded profile. Its morphology was consistent with the documented tree throw ground disturbances. Feature 120 exhibited a narrow, shaft-like configuration. In form, this basin bears a strong similarity to a conifer (pine) tree stump/tap root mold. In contrast to deciduous trees, which were shown to leave shallow, saucer-like depressions, pines often leave a narrow vertical disturbance extending a considerable distance below grade. This was demonstrated by BX 14 and BX 2. BX 14 showed a deep narrow sub-grade disturbance while BX 2 revealed a very large, vertical taproot in proportion to tree size. As a group, the large basins (Features 2, 77, 90, 118, 169) bear some similarities to observed tree throw morphologies. In planview, the large basin features

displayed the oval to crescentic plan configuration documented for the tree throw disturbances (Langhor 1993). However, when comparing the basins to tree throws documented in the present study, the tree throw disturbances were shown to be significantly shallower than the large basin features. The large basins also did not exhibit the diffuse and indistinct edges typically observed in the tree bisections and tree throw disturbances.

Postdepositional Effects. Each of the basin features was reviewed for evidence of postdepositional disturbances such as rodent burrowing, extensive root channeling and similar phenomena. The large basin features did not exhibit signs of disturbance other than minor root channeling and general bioturbation expected of an archaeological entity. Medium basin Feature 3 intersected with an adjacent basin feature and had also been intruded upon by roots and/or rodent tunnels. Feature 116 exhibited a relatively large amount of disturbance in the form of root and/or rodent channels. The banded stratification in Feature 120 is considered consistent with the results of infilling of a narrow disturbance through erosion and internal slumping.

Basin Content

Elevated Artifact Counts. The presence of elevated numbers of artifacts within a basin is seen as key indicator for a cultural association. While the presence of elevated numbers of basin artifacts in relation to adjacent non-feature contexts is not necessarily indicative of a cultural formation, it does suggest that the ground surface disturbance was open during the site occupation. Strongly inflated artifact counts are seen as indicative of the basin having been deliberately utilized for refuse disposal. Decreases in basin artifact densities, in relation to adjacent non-basin contexts, however, are not necessarily seen as a negative indicator for a cultural formation. Rather, this suggested that the basin's formation, whether natural or cultural, predated the bulk of the site occupation. Decreases in relative artifact counts for basin contexts may also be potentially the result of deliberate cultural deposition of artifacts following the basin infilling.

Relative artifact density values (inside versus outside basin context) expressed in artifacts per m² were used to address whether the ground surface disturbances may have been utilized for the disposal of refuse. Values expressed in artifacts per m³ (basin volume) fail to control for potential natural and cultural infilling processes, which can occur both before and after the cultural deposition of artifacts (primary deposit). This can operate to greatly distort relative artifact density values. Specifically, relative artifact densities expressed in m² were used to assess whether the artifacts recovered from basin contexts were the result of the interruption of an occupation surface, or whether the physical interruption of the ground surface plane (basin) was culturally utilized.

Calculation of feature and non-feature area densities was a multi-stepped process that employed Geographic Information Systems (GIS) to aid in computing the total area and the corresponding artifact count. The total feature area was calculated by computing the sum of the feature area by test unit. This process was used to produce a more accurate total area and to examine potential differences of artifact density within a single feature. The number of artifacts that were recovered from the feature in each unit was then derived, and this total was divided by the sum of all feature areas, to provide the artifact per m² value. To achieve the most comparable results between feature and non-feature contexts, a similar methodology was employed. The

majority of features on the site and those within this feature sample were identified at the base of the A-horizon. Therefore, artifacts from the A-horizon within units were not included in the computation for non-feature area artifact density.

To establish non-feature artifact density per unit, the feature area was subtracted from the unit area (usually 1 m). This procedure was conducted for the units that included the feature edges. When available, and to provide a wider control, test units that were adjacent to, but did not contain the feature in question, were included. In areas with overlapping and intersecting features, non-feature areas were comparatively small; this was especially true around Features 77, 169, 234, and 267. Feature 202 was located within the backhoe strip, which was not subjected to controlled excavation and, therefore, had no immediately adjacent non-feature artifacts with which to compare. As a result, the two nearest test units, located about 3 m south and east, were utilized as a comparative control. All of the available non-feature areas were then summed for the total non-feature area considered. The below A-horizon artifacts recovered from these areas were also summed and then divided by the total non-feature area to provide the non-feature artifact density per m² value.

The calculated values of artifact density were comparable (Table 10.5). However, some caveats are warranted. In several cases, basins considered in the study were located near or adjacent to evident TAS clusters, for example Features 139 and 169. The non-feature artifact densities around those TAS clusters were likely inflated due to the dispersion of TAS artifacts from the visible boundaries of the TAS features. In addition, the calculated areas in locations with overlapping features contained error, due to the inability to adequately account for areas of overlap; this was especially true of Features 77 and 234.

GIS based plots were generated to illustrate the artifact counts within each feature by unit, as well as the non-feature proveniences in the adjacent units. These figures show total artifact counts and are not displayed in artifact density per square meter, but provide for a means of visual comparison within and between features (Appendix C).

Several basin features clearly contained elevated artifact numbers. Feature 90, a large basin, yielded over 800 artifacts (Figure 10.82). This represented a relative increase by a factor 1.3 against adjacent non-feature contexts. A second large basin, Feature 118, contained 71 unidentified (weathered) ceramic sherds (Figure 10.83). This feature was situated along the site periphery in an area that otherwise yielded very little cultural material. Artifact density within Feature 118 represented an increase by a factor of 3.8.

Feature 120 contained artifact assemblage suggestive of purposeful cultural input (Figure 10.84). Early and Middle Woodland ceramic sherds, debitage and TAS fragments were recovered from a discrete stratum near the top of the feature. This stratum was notably darker and more organic than the lower strata, which were also devoid of cultural material. Also recovered in association with the artifacts was a calcined bone fragment and carbonized nut hulls and wood charcoal. This represented a relative increase by a factor of 2.7 over adjacent non-feature contexts.

Table 10.5 Tabulation of the Feature Areas, Volume and Artifact Densities***Large Basins (B-1)***

Feature	Type	Total Artifacts	Feature Volume in Liters (est.)	Feature Artifact Density per 100 Liters	Feature Area in m ²	Feature Artifact Density per m ²	Non-feature Artifact Density per m ²
2	B-1	164	5058.1	3.2	7.41	22.1	27.2
77	B-1	656	5260.3	12.4	4.46	147.0	191.3
90	B-1	899	6158.0	13.7	7.27	123.6	46.6
118	B-1	73	1208.6	6.0	3.13	23.3	6.1
169	B-1	238	2878.1	8.2	5.10	46.6	137.0

Medium Basins (B-2)

Feature	Type	Total Artifacts	Feature Volume in Liters (est.)	Feature Artifact Density per 100 Liters	Feature Area in m ²	Feature Artifact Density per m ²	Non-feature Artifact Density per m ²
3	B-2	10	436.8	2.2	1.09	9.1	4.9
67	B-2	38	235.0	16.1	0.89	42.6	69.0
139	B-2	118	426.6	27.6	0.91	129.6	226.4
234	B-2	117	429.0	27.2	1.79	65.3	23.9
298	B-2	42	274.1	15.3	1.57	26.7	102.6
314	D-2	2	19.1	10.4	N/A	N/A	46.3

Small Basins (B-3)

Feature	Type	Total Artifacts	Feature Volume in Liters (est.)	Feature Artifact Density per 100 Liters	Feature Area in m ²	Feature Artifact Density per m ²	Non-feature Artifact Density per m ²
4	B-3	13	17.1	76.0	0.18	72.2	58.8
116	B-3	0	8.8	0.0	0.14	0.0	3.2
120	B-3	29	246.6	1.7	0.33	87.8	32.8
202	B-3	12	12.9	93.0	0.09	133.3	39.0
267	B-3	2	28.9	6.9	0.08	25.0	57.0

Tree Mold Features (D-2)

Feature	Type	Total Artifacts	Feature Volume in Liters (est.)	Feature Artifact Density per 100 Liters	Feature Area in m ²	Feature Artifact Density per m ²	Non-feature Artifact Density per m ²
20	D-2	0	161.4	0.0	0.18	0.0	1.2
63	D-2	8	260.2	3.0	1.63	4.9	61.5
119	D-2	1	9.9	10.1	0.17	5.8	16.3
126	D-2	0	19.8	0.0	0.03	0.0	1.0
314	D-2	2	19.1	10.4	N/A	N/A	46.3

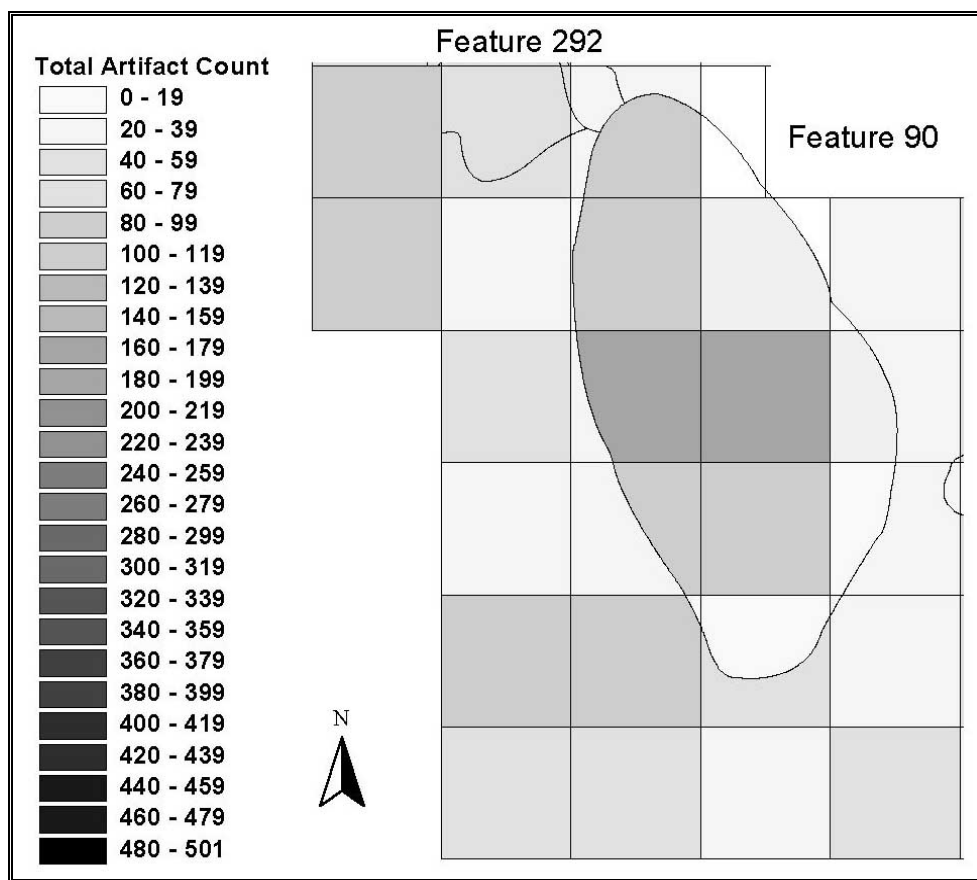


Figure 10.82 GIS Generated Planview with Artifact Content of Feature 90

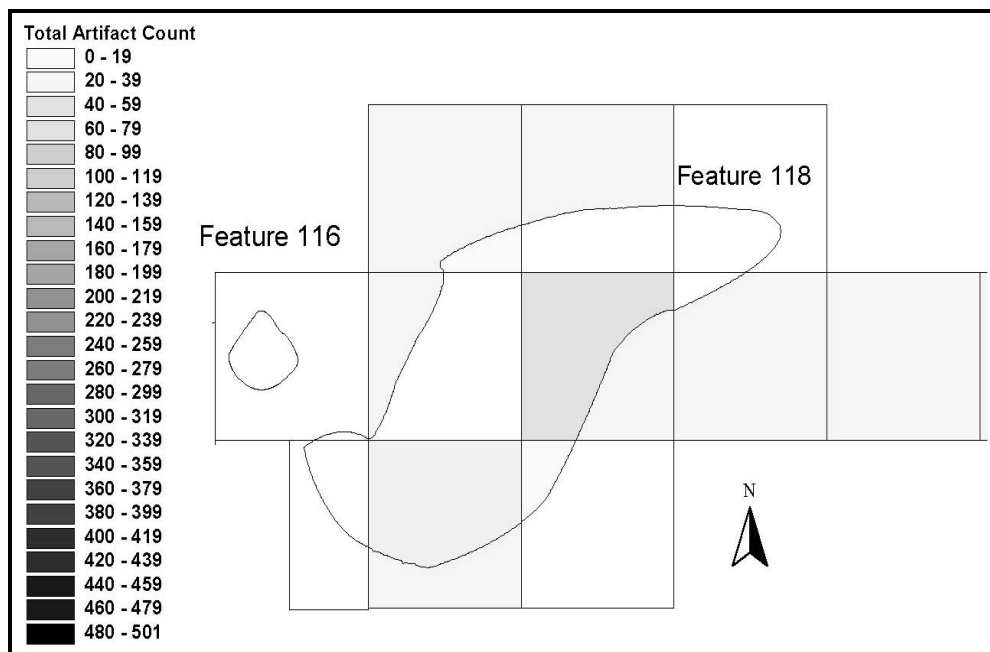


Figure 10.83 GIS Generated Planview with Artifact Content of Feature 118

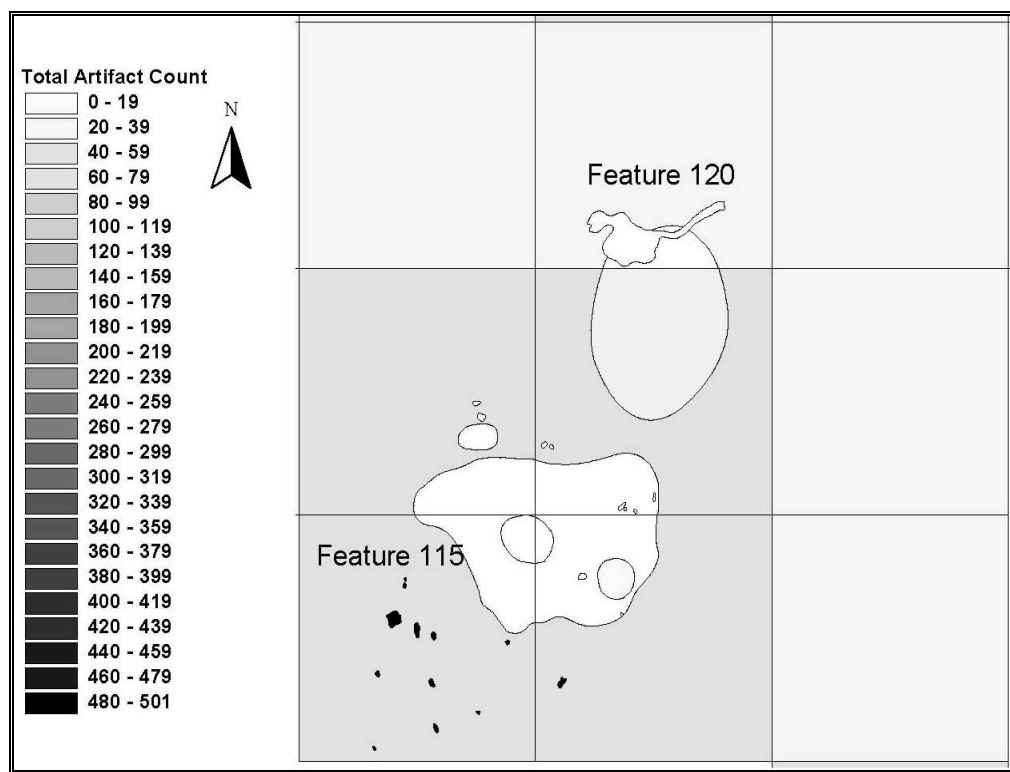


Figure 10.84 GIS Generated Planview with Artifact Content of Feature 120

Medium basin Features 3 and 234 yielded significantly elevated numbers of artifacts (Figure 10.85 and Figure 10.86). Features 139 and 298 exhibited decreased artifact densities compared to surrounding non-feature units (Figure 10.87 and Figure 10.88).

Only two tree mold features, Features 63 and 119, contained sufficient artifacts numbers to allow for statistical comparison against non-disturbance contexts. Both contained decreased levels of cultural materials relative to the surrounding matrix (Figure 10.89 and Figure 10.90).

Small basin Feature 202 also yielded elevated numbers of artifacts (Figure 10.91). In contrast to the above features (except for Feature 120) into which artifacts appear to have been haphazardly discarded, the items in Feature 202 were identified in a configuration that indicated deliberate placement. Evidence of deliberate placement aside, the Feature 202 artifact counts represented an increase by a factor of 3.4 over adjacent non-feature context.

Geochemistry. Geochemical analysis was conducted on four of the five large basin features (Features 2, 77, 90, 169). These large basin features were shown to have particularly high levels of phosphorous (P) viewed to be result of the archaeological presence of P-rich, organic material (Section 9.0). In addition, the elevated P levels recorded in absence of any actual organic matter were seen as suggestive that the material from which the P was derived was associated with the basins original use/formation rather than having been introduced through disturbances such as roots or rodent action. The presence of P in relative combination with other chemical markers suggested that some of the P contributing material may have been bone (Section 9.0). These results suggested that Feature 2, 77, 90 and 169 were open and had accumulated culturally generated organic waste during the site occupation.

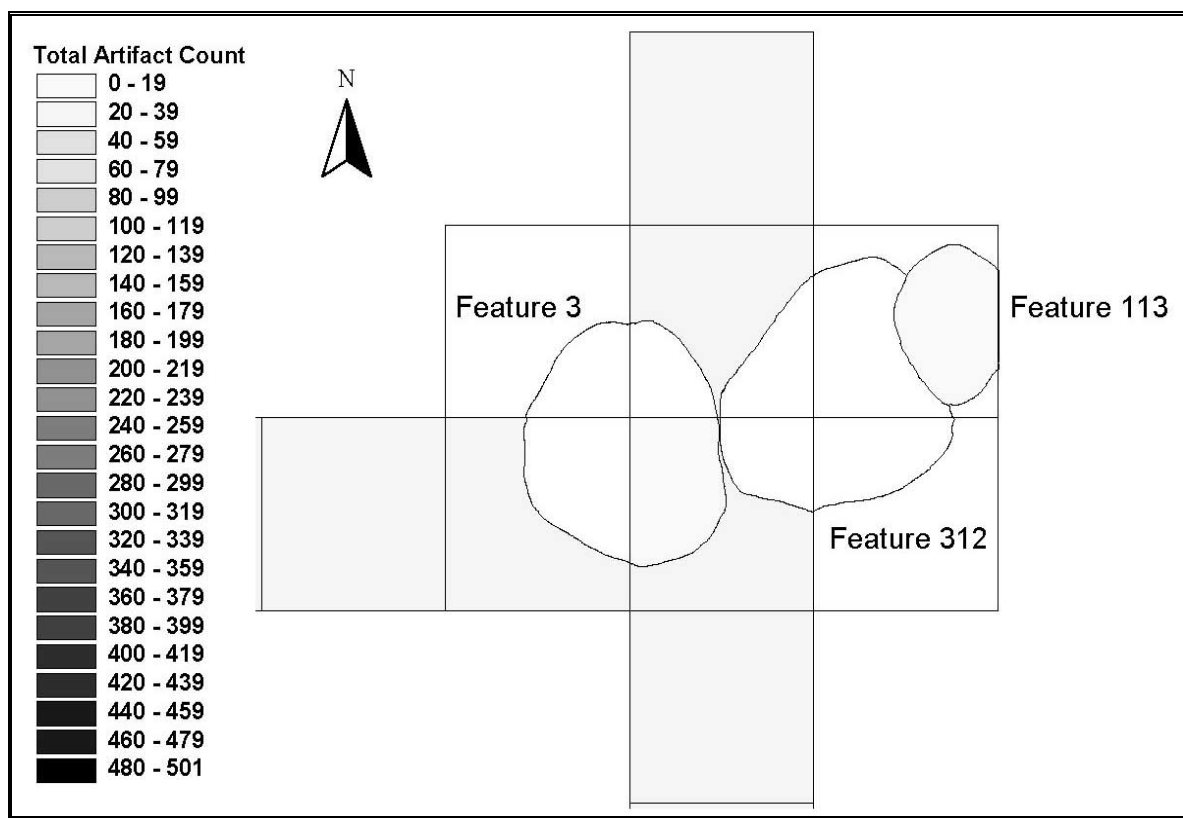


Figure 10.85 GIS Generated Planview with Artifact Content of Feature 3

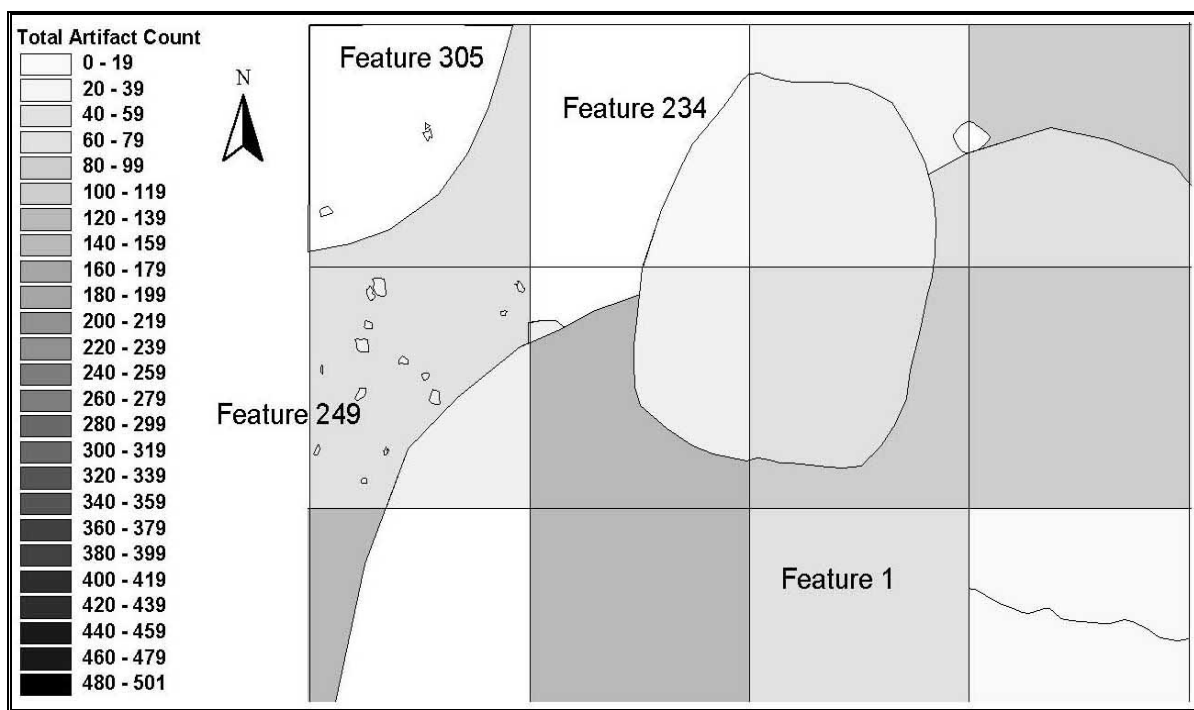


Figure 10.86 GIS Generated Planview with Artifact Content of Feature 234

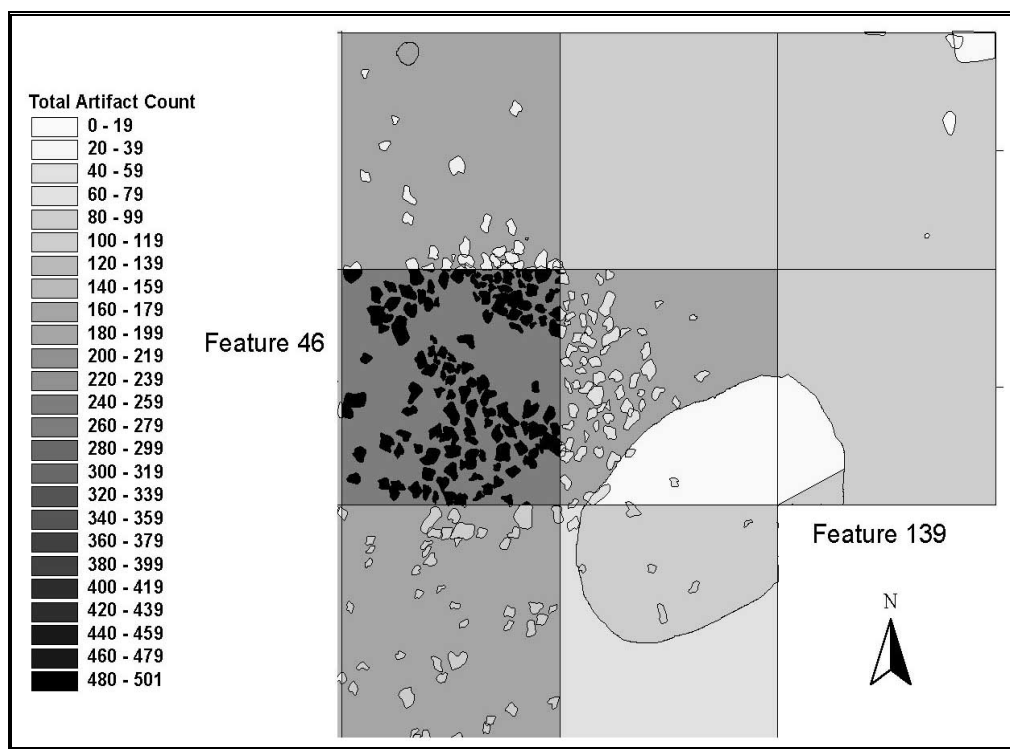


Figure 10.87 GIS Generated Planview with Artifact Content of Feature 139

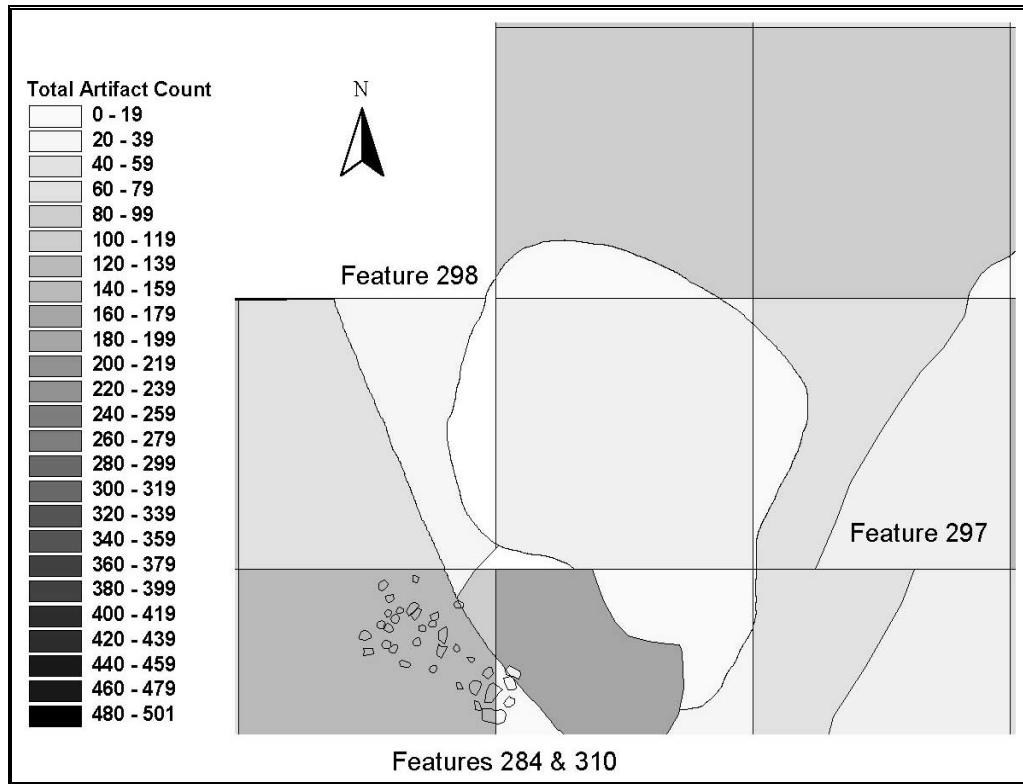


Figure 10.88 GIS Generated Planview with Artifact Content of Feature 298

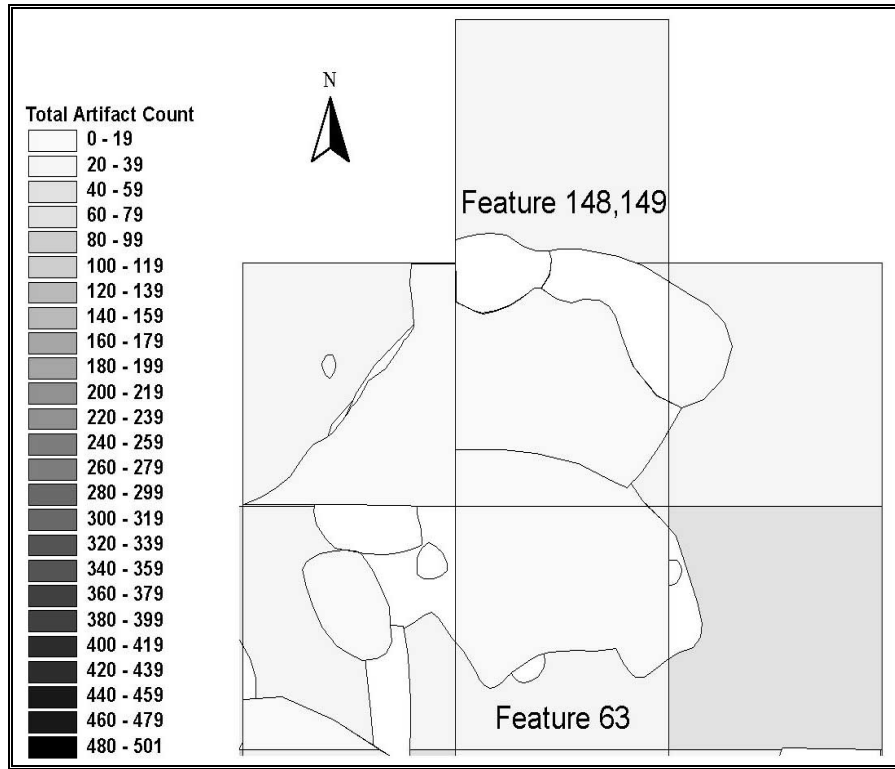


Figure 10.89 GIS Planview with Artifact Content of Feature 63

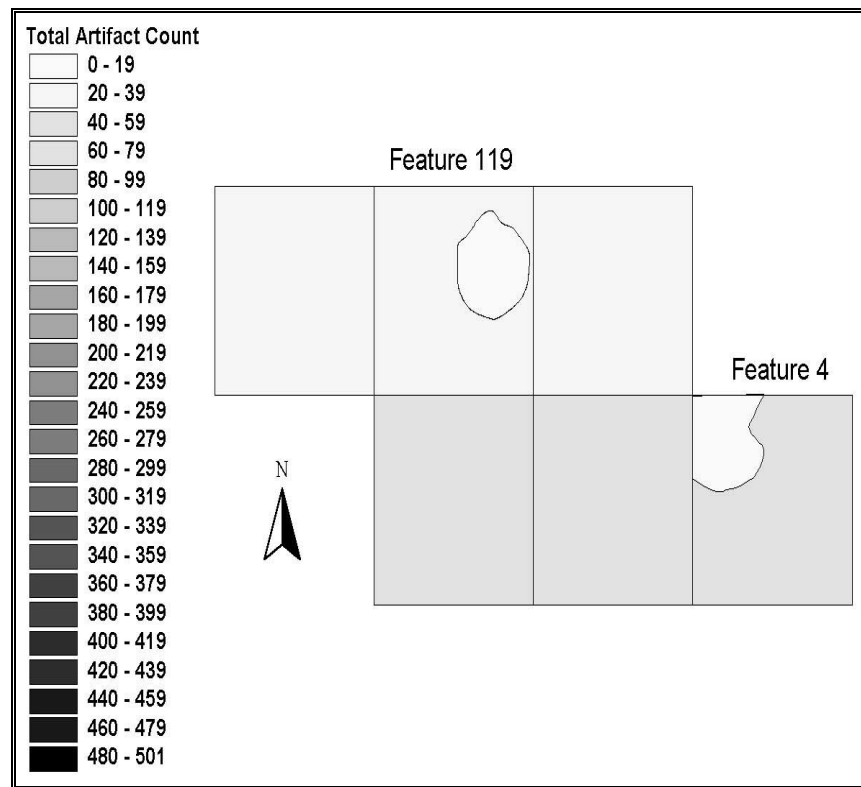


Figure 10.90 GIS Generated Planview with Artifact Content of Feature 119

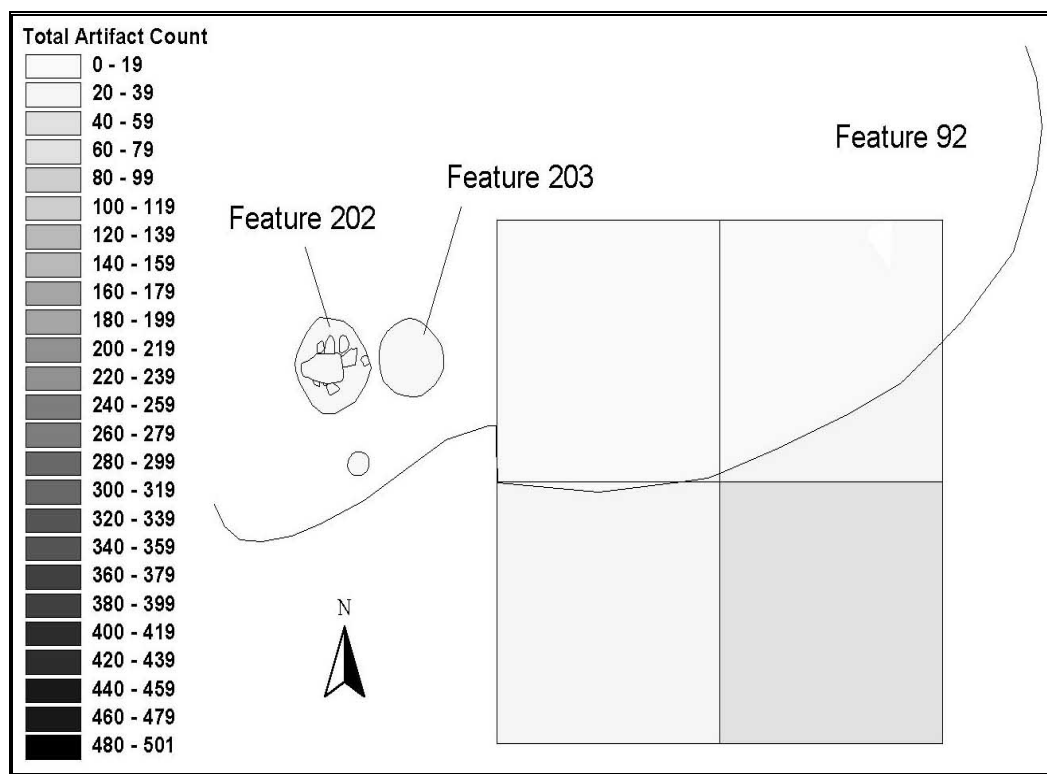


Figure 10.91 GIS Generated Planview with Artifact Content of Feature 202

Component Period Ecofacts (AMS Dating). Of the 15 basins in this feature sample, six were subjected to radiocarbon (AMS) dating. Features 2, 3, 4, 90, and 120 yielded Woodland I period dates coeval with major site occupation components recognized through the recovery of chronologically diagnostic artifact types. Results of the radiocarbon dating are tabulated in Table 10.6.

Summary Results of Basin Feature Analysis

Feature 2 was a large basin. In planview, the basin conformed to documented tree throw morphology. In profile, the feature was considerably deeper than the observed tree throw forms. Analysis of the basin content did not indicate elevated artifact numbers. Geochemical analysis of the fill suggested cultural input. An occupation period radiocarbon date of 2790 \pm 40 years B.P. was obtained from the feature.

Feature 3 was a medium basin that did not exhibit any clear tree related or cultural morphologies. Elevated numbers of artifacts were present in comparison to immediately adjacent non-basin contexts. No geochemical analysis was performed. The feature yielded two overlapping occupation component period radiocarbon dates of 2600 \pm 60 years B.P. and 2790 \pm 60 years B.P.

Table 10.6 Summary of Basin Feature Attributes***Large Basins (B-1)***

Morphology				Content			
Feature	Tree Rot Morphology	Tree Throw Morphology	Cultural Morphology	Post-depositional Disturbance	Elevated Artifacts	Anthro Geochemistry	Radiocarbon Dating
2	No	Partial	No	Minor	No	Yes	2790+/-40 years B.P.
77	No	Partial	No	Minor	No	Yes	N/A
90	No	Partial	No	Minor	Yes	Yes	4070+/-40 years B.P.
118	No	Partial	No	Minor	Yes	N/A	N/A
169	No	Partial	No	Minor	No	Yes	N/A

Medium Basins (B-2)

Morphology				Content			
Feature	Tree Rot Morphology	Tree Throw Morphology	Cultural Morphology	Post-depositional Disturbance	Elevated Artifacts	Anthro Geochemistry	Radiocarbon Dating
3	No	No	No	Yes	Yes	N/A	2600+/-60 years B.P. 2790+/-60 years B.P.
67	No	No	Yes	Minor	Yes	N/A	N/A
139	No	No	No	Minor	No	N/A	N/A
234	No	No	Yes	Minor	Yes	N/A	N/A
298	Partial	Partial	No	Unknown	No	N/A	N/A

Small Basins (B-3)

Morphology				Content			
Feature	Tree Rot Morphology	Tree Throw Morphology	Cultural Morphology	Post-depositional Disturbance	Elevated Artifacts	Anthro Geochemistry	Radiocarbon Dating
4	No	No	Yes	Minor	Yes	N/A	1540+/-50 years B.P.
116	Yes	Partial	No	Yes	No	N/A	N/A
120	Yes	No	No	Minor	Yes	N/A	920+/-50 years B.P.
202	No	No	Yes	Minor	Yes	N/A	N/A
267	No	No	No	Minor	No	N/A	N/A

Feature 4 was a small basin. Its cylindrical form is viewed as being cultural in origin. While the feature yielded artifact numbers that were only slightly elevated in numbers relative to adjacent contexts, they were recovered from an apparent primary deposit at the base of the feature. An occupation component period radiocarbon date of 1540 \pm 50 years B.P. was obtained from wood charcoal recovered from the fill.

Feature 67, a medium basin, exhibited an apparent cultural morphology that included regular shaped sides and a flat bottom. The basin was shown to have decreased numbers of artifacts over adjacent non-feature contexts. Other than the basin morphology, no other data were available.

Feature 77 was a large basin. In planview the feature exhibited the oval to crescentic form documented for tree throw morphologies. In profile, however, the feature had a considerably greater depth than the observed tree throws. The fill did not contain elevated numbers of artifacts. Geochemical analysis revealed elevated levels of phosphorous, which is viewed as evidence for cultural input.

Feature 90 exhibited the same partial tree throw morphology as the other large basins in the feature lot. Planview was oval to oblong, with a deep, asymmetrical profile. Feature 90 contained elevated artifact numbers and geochemical signatures indicative of a cultural input. It appears that the basin was naturally formed, and cultural material was subsequently introduced.

Feature 116 exhibited tree mold morphology. It was shallow with irregular sides. Several linear disturbances were noted extending from the central core. However, it remains undetermined if the basin was purely a tree mold, or if multiple formation processes were represented. No artifacts were recovered from the feature fill.

Feature 118 was a large basin with partial tree throw morphology. The feature fill yielded elevated artifact numbers indicating that, as a ground surface disturbance, the feature was extant during site occupation. The basin appears to have captured cultural material after its formation. No geochemical or AMS data was available for the basin.

Feature 120 had a morphology that was consistent with a pine tree stump/tap root mold. The lower two-thirds of the feature fill were devoid of artifacts. The interbedding of sandy, culturally sterile soils within the lower portion of Feature 120 suggests internal slumping of soils within a deep narrow disturbance. The feature contained elevated artifact numbers in relation to immediately adjacent non-feature contexts. Elevated numbers of artifacts and other cultural material were recovered from discrete strata within the upper portion of the fill. An occupation component period date of 920 \pm 50 years B.P. was obtained from the upper portion of the feature. Overall, the morphological and content attributes of Feature 120 suggested a formation consisting of a tree stump/taproot void that captured cultural material.

Feature 139 did not exhibit clear tree related or cultural morphologies. Analysis demonstrated that the feature contained relatively fewer artifacts than surrounding area. Fill was atypical for basin features in that it was sandier and lighter in color than the undisturbed matrix soil.

Feature 169 exhibited the partial tree throw morphology common to the large basins in this feature sample. Relative counts inside the feature were lower than adjacent non-feature contexts. Results of geochemical analysis were suggestive of a cultural input.

Feature 202 was a small basin that had a regular, symmetrical morphology viewed as being cultural in origin. The basin also contained artifacts in a configuration that was clearly indicative of deliberate placement. The basin feature represented a deliberate excavation in which artifacts were interred. Statistical analysis also showed the presence of elevated artifact numbers.

Feature 234 was a medium basin that appeared to have a cultural morphology. This was seen in its well-defined edges, steep side walls and bluntly rounded bottom, which gave the basin a bilaterally symmetrical form. The feature contained elevated artifact numbers in comparison to the surrounding non-feature soil matrix.

Feature 267 was a small basin that also exhibited a bilaterally symmetrical form. The steep, well-defined sides and bluntly rounded bottom are viewed as evidence of a cultural formation. The two TAS fragments and two carbonized nut hulls recovered from the feature may also be suggestive of cultural activity.

Feature 298 was a medium basin exhibiting tree-related morphology. This was expressed in its irregular, shallow saucer-like configuration and indistinct sides. Its shape and dimensions are consistent with observed modern tree throw disturbances. Relative artifact counts were less than adjacent non-feature contexts.

HISTORICAL INFLUENCES ON HICKORY BLUFF FEATURES

From 1905 to 1995, the eastern portion of Hickory Bluff was an apple orchard (Appendix A). Initial field preparation, planting of the orchard, operation and maintenance, and eventual abandonment, neglect and destruction contributed to the postdepositional processes acting on this portion of the site. Remnant tree molds or tree throws resulting from the abandonment and destruction of the apple orchard may have contributed to discontinuities observed in the two linear backhoe stripped areas of Hickory Bluff.

The Apple Orchard

Rectangular and hexagonal orchard planting configurations were both common planting strategies available to early twentieth century farmers. Trees planted in a square or rectangular pattern at a 30-foot spacing could accommodate up to 48 trees to the acre. Hexagonal planting could incorporate up to 15 percent more trees per acre (up to 55 trees) than the rectangular system (Paddock and Whipple 1913:42; Figure 10.92). The square or rectangular method of planting was apparently the most satisfactory method of planting an orchard (Paddock and Whipple 1913:42). The hexagonal method did not have wide middle areas and could not accommodate large, modern, orchard machinery (Paddock and Whipple 1913:42). To get a maximum of 55 trees to an acre, and still use the square or rectangular system, journals suggested a distance of 26 feet between trees and 30 feet between rows, although some journals recommended a spacing as wide as 50 feet for apple trees (Paddock and Whipple 1913:46).

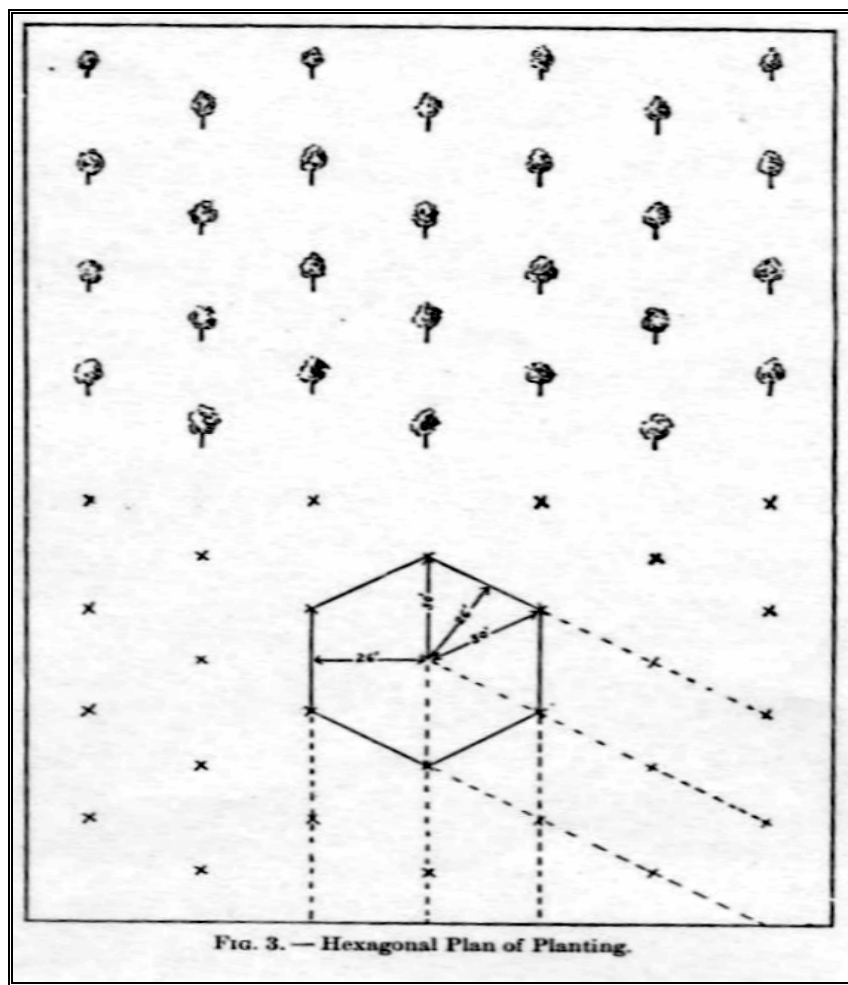


Figure 10.92 Schematic of the Hexagonal Tree Planting Pattern for an Orchard, circa 1913
(Paddock and Whipple 1913:42)

A 1926 Army Air Corp aerial photograph for the Hickory Bluff vicinity indicated that only the eastern portion was contained within a fruit orchard, which extended halfway between the St. Jones River and Route 113 (Figure 10.93). A rectangular planting scheme was utilized at that time. Based on the aerial photograph, the average spacing between the trees was approximately 10 m (30 feet).

A 1937 DelDOT aerial photograph for the site indicated the eastern portion of the site still was contained within the orchard, which extended the most of the length of the tract from near the St. Jones River to Route 113 (Figure 10.94). The patterning of the trees shows both rectangular and hexagonal planting strategies on the parcel. The average spacing between the trees remained at approximately 10 m (30 feet).

Backhoe Features

Two areas of Hickory Bluff were mechanically stripped: the area for a proposed drainage ditch (Liebeknecht et al. 1997) in the southern portion of the site and a 6 x 120 m linear area within the northern portion of the site. Sixty-three features were identified in the plowed field/

orchard portion of the proposed drainage ditch and consisted of both large ($n=30$) and smaller basins ($n=33$). Depths, as determined by soil probes, varied from 15 cm to 90 cm. Fifty-four features were identified in the north backhoe strip area; 19 features occurred in the plowed field/orchard portion (Table 10.7).

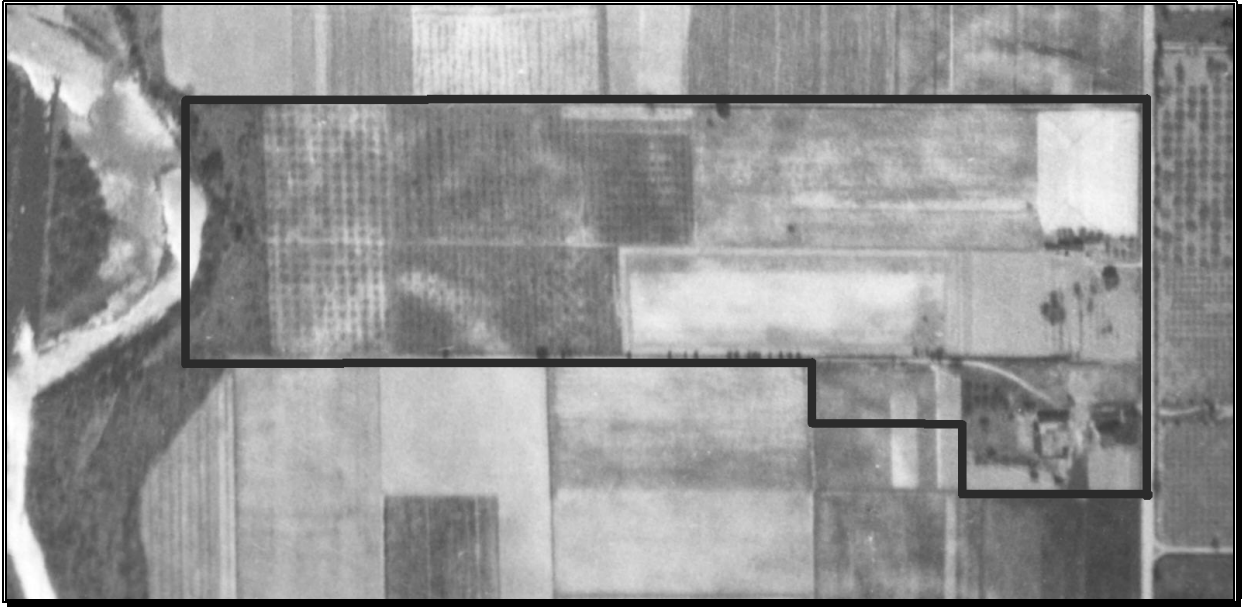


Figure 10.93 1926 Army Air Corp Aerial Photograph Depicting the Apple Orchard at Hickory Bluff

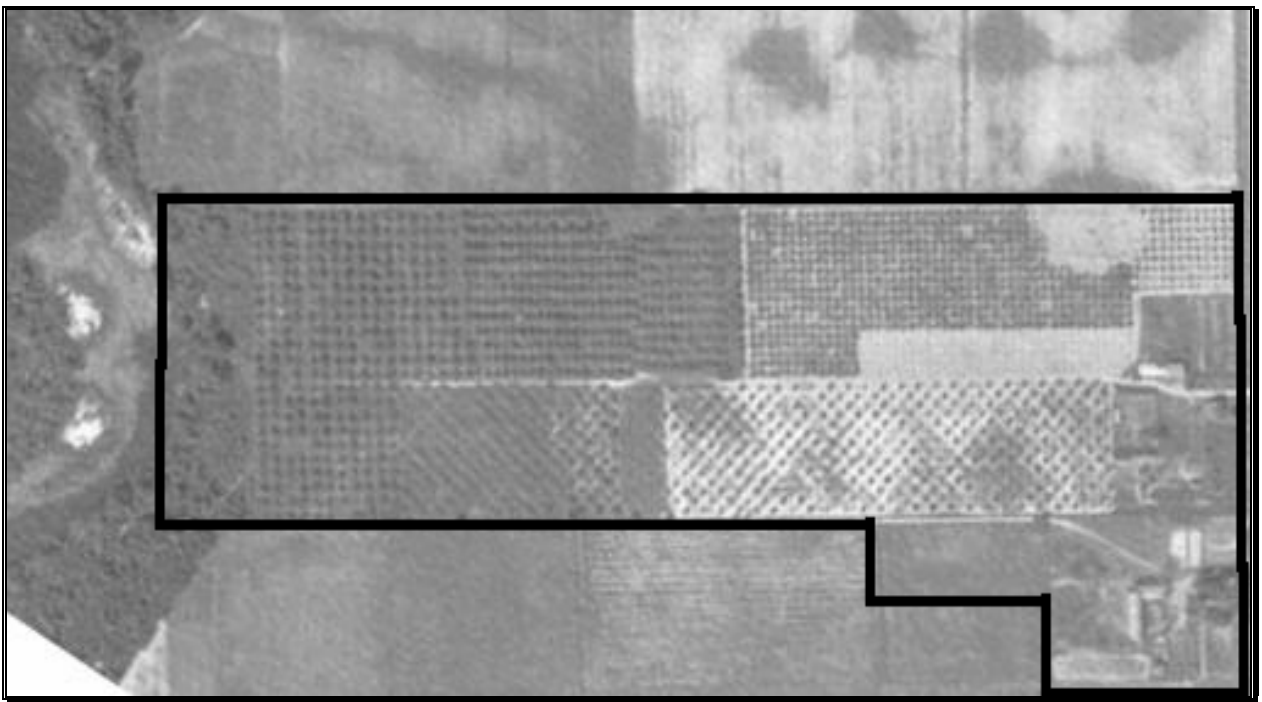


Figure 10.94 1937 DelDOT Aerial Photograph Illustrating Expansion of the Apple Orchard at Hickory Bluff

**Table 10.7 Hickory Bluff Features Located in the Plowed Area
of the North Backhoe Strip**

Feature Type	A	B	C	D	E	F
Feature Number	229, 240, 246	243, 253, 266, 269	none	218, 220	none	223, 237, 238, 239, 241, 242, 245, 247, 248, 256

The orchard grid pattern was derived from the aerial photographs, scaled, and superimposed on the feature locations in the plowed portion of Hickory Bluff (Figure 10.95). Although feature patterning in the south backhoe strip was linear, few features intersected with the superimposed orchard grid. Because of the narrowness of the north backhoe strip (only 6 m or about 18 feet), feature correspondence with the orchard grid was problematic. Even though evidence of tree molds and tree throws from the abandonment and destruction of the historical apple orchard would be expected, few of the features identified through mechanical removal of the plow zone corresponded with orchard tree locations.

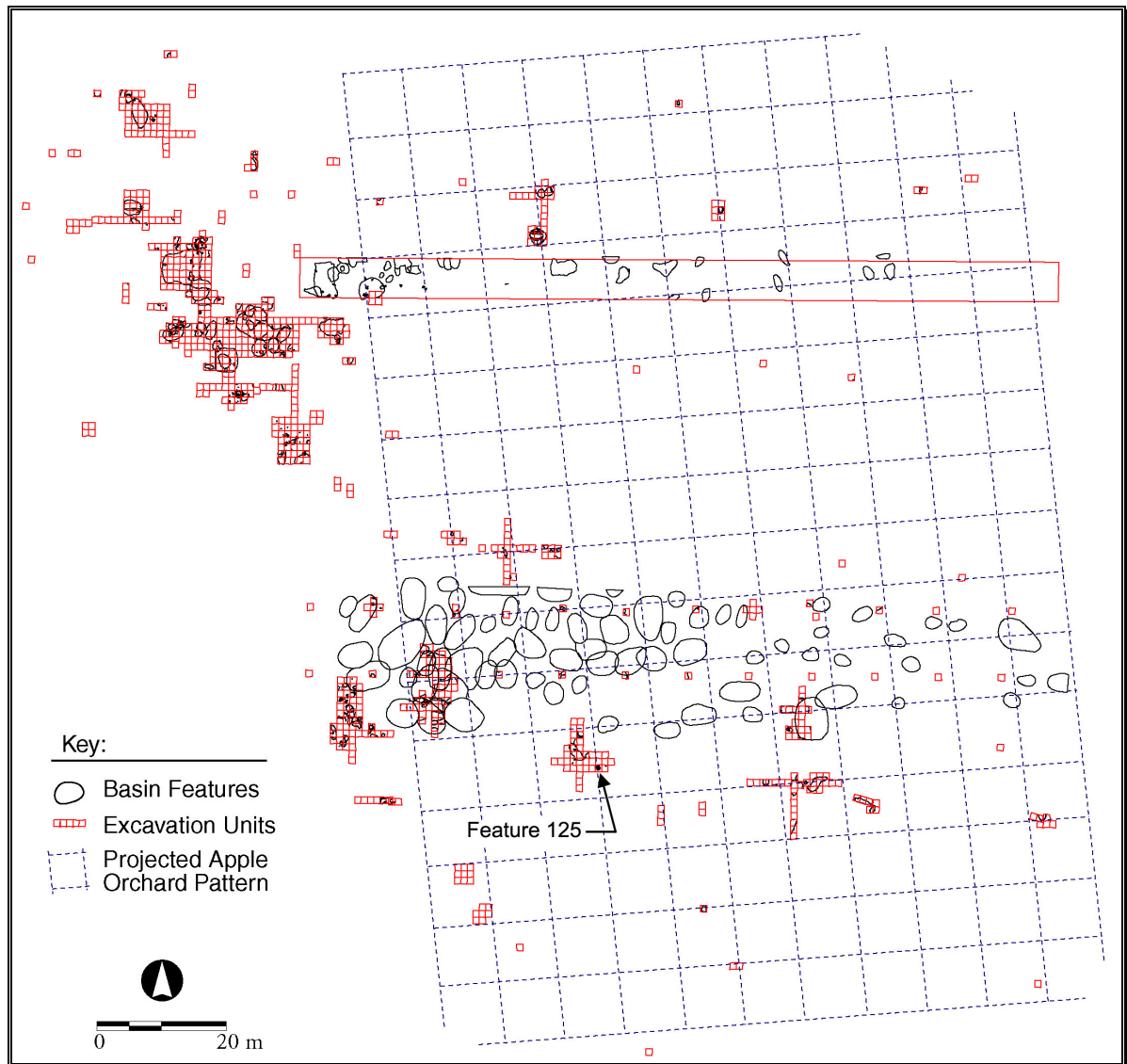


Figure 10.95 Orchard Grid Overlay on Hickory Bluff Basin Features